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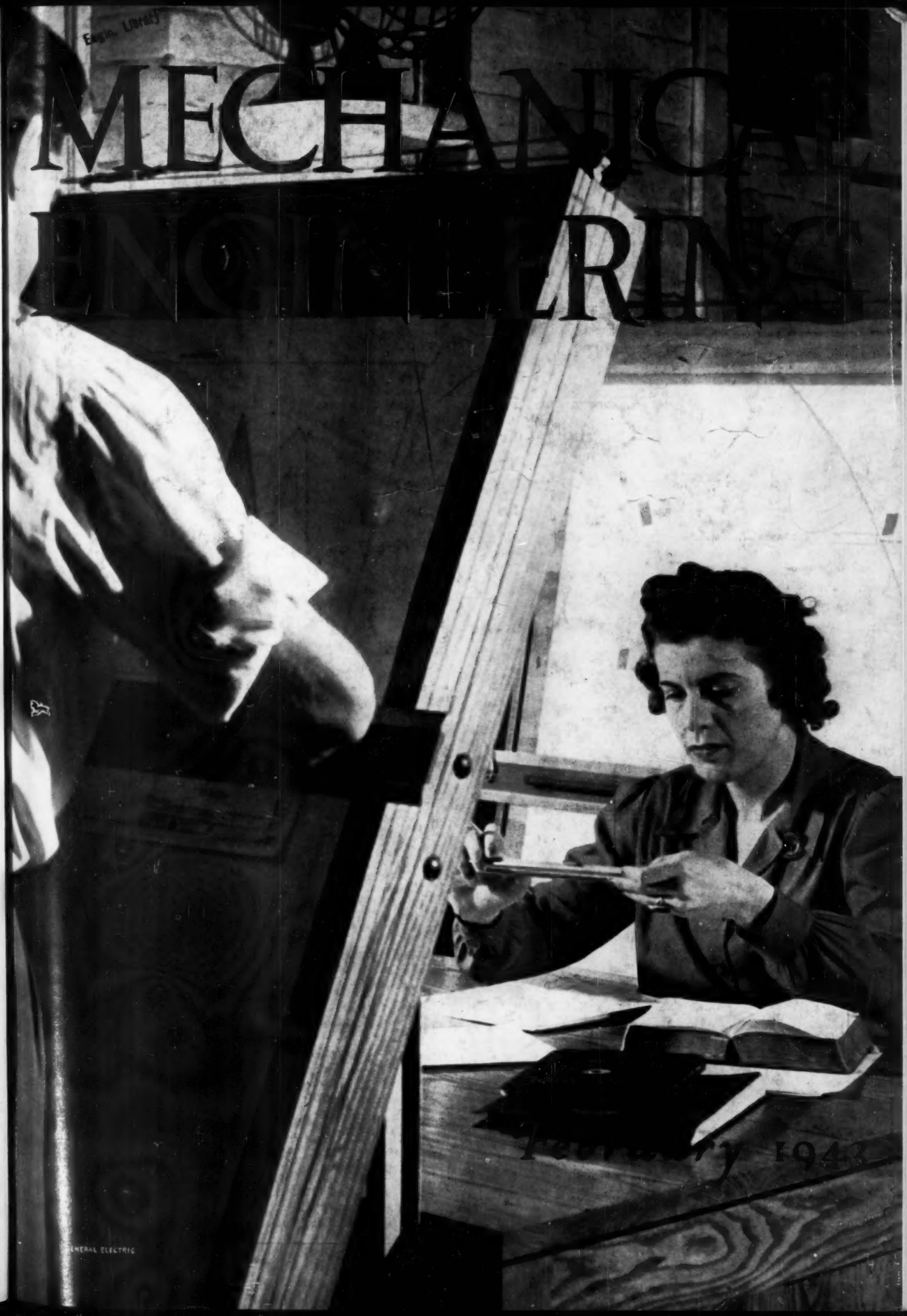

January 1943

GENERAL ELECTRIC

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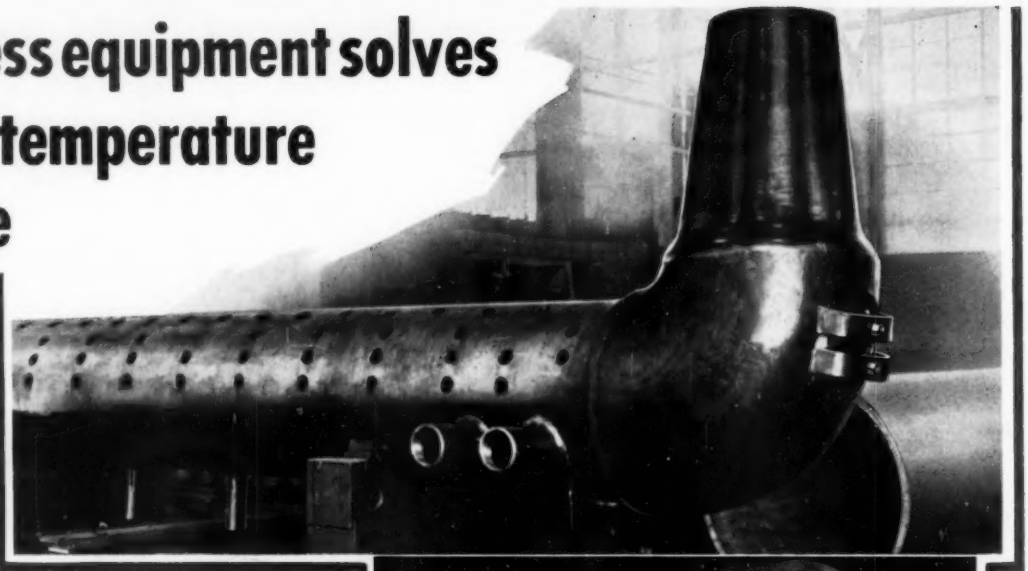

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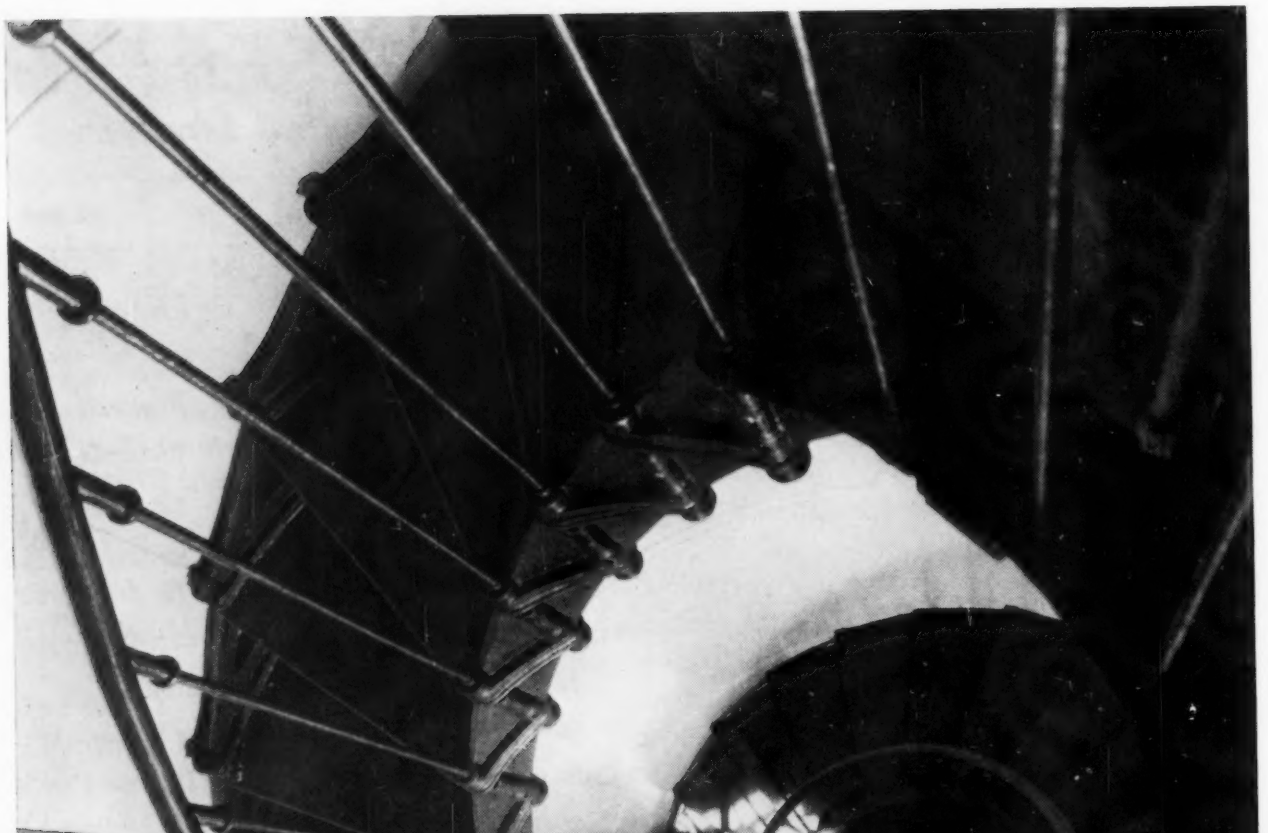


Cushing

Descending Spiral

VOLUME 65
No. 2

MECHANICAL ENGINEERING

FEBRUARY
1943

GEORGE A. STETSON, *Editor*

Carver's Lesson

ANYONE who ever met Dr. George Washington Carver will undoubtedly carry with him always a mental picture of that truly remarkable scientist. His simple modest manner, soft voice, and gentle ways were immediate revelations of the nobility of his character. As one listened to his words and pondered their significance, the intellectual stature of the man grew to the point of commanding profound respect. Contemplating his simple dignity amid the reverential adoration of the humbler members of his own race who surrounded him, one could only reproach oneself in humility, remembering that "to whomever much is given, of him shall be much required." For most of us, in contrast to him, "born to the purple," the flush of some petty achievement will turn to a blush of shame, and the realization of our own poorly used opportunities becomes acute.

Dr. Carver typified the glorification of the humble. Nothing could have been more lowly and earth-bound than his origin. The handicap of this origin he converted into an intellectual and moral triumph. The flowering of his intellect was forever sustained by roots running deeply into that lowly and earth-bound environment. He never lost contact with it. Even his scientific work, which lay with such earthy things as sweet potatoes and peanuts, was in itself a glorification of the humble. He drew strength from the soil, uncovered the riches that lay in humble things, and showed his fellow men how they might exercise knowledge to transform the natural products of the earth into useful products.

The world today needs to take the lesson of Dr. Carver's achievement to its heart. At a time when science has developed to a point where all material wants of humanity can be satisfied by the transformation of want into plenty through the use of knowledge and a reasonable amount of hard work, millions are starving and nations are attempting to harvest where they have not sown.

Shut off by their environment from the easier ways of living, the Eskimos have learned to make intelligent use, for their principal needs, of the flesh, the oil, the bones, the skins, and the sinews of beasts and fish. Like Dr. Carver, they have taken what has been available to them and transformed it to meet their needs. Human intelligence has triumphed in both these cases and the faith is sustained that civilized nations may yet find in these examples better ways of living. Science and engineering provide the means by which this end may be brought about if men will heed the lesson of Dr. Carver's life.

The Traffic Problem

STRICT gasoline rationing has driven from the streets of our cities most of the automobiles which formerly occupied them. To many persons this relief in traffic congestion is gratefully welcomed and, except as we ourselves may wish to use our own cars, we think how splendid it would be if there were never again the traffic jams of the past. Having of necessity got rid of them, we have no desire to see them return.

Must they return? In the past we have been devising costly and confusing ways of handling more and bigger automobiles, trucks, and busses. Perhaps we have thought too little about handling people quickly, comfortably, and economically. Is it beyond the intelligence of engineers and municipal authorities to work out a reasonable solution to this problem? The present emergency affords an excellent opportunity for thinking about the problem and seeking a solution. This is one phase of postwar planning that can be started today. Fundamentally, it is an engineering, as well as a city-planning, problem.

A.S.M.E. Promotes Safety

ON THIS page last month attention was directed to the organization of the War Production Fund to Conserve Manpower, under the auspices of the National Safety Council.

Because accidents are so frequent, so unexpected, and arise from such trivial incidents, in many cases, all of us are constantly exposed to them and all of us acquire careless habits which contribute to their frequency and severity. Some of the most hazardous industries have the best accident records. The reason, of course, lies in the fact that where danger is obviously present, men are likely to be conscious of it and exercise care, and managements institute severe disciplinary measures. It is once more a case of eternal vigilance which in itself can become a habit if one puts one's mind to it.

Accidents that result from the careless habits of individuals are everybody's business. Failures of machinery and structures, which are likely to be spectacular and costly, arouse public indignation. They result in the fixing of responsibility and in laws regulating design, construction, and operation. In this country, where the police power is vested in the states, the well-intentioned efforts to provide for the public safety are likely to result in a variety of laws and rules. The designer and the manufacturer may find what is required in one state

is banned in another. Under such conditions safety may be purchased at the expense of needlessly uneconomical practices.

It was out of such conditions that the A.S.M.E. Boiler Code grew. By means of sound and intelligent procedure, the A.S.M.E. Boiler Code has become accepted in most states. Designers and manufacturers adhering to the code know that their boilers will meet the demands of the authorities of the states in which they are to be installed and operated. The public safety is safeguarded, practicable and economical manufacture is assured, and the art of boiler construction is placed on a sound basis.

The work of the A.S.M.E. Boiler Code Committee is a conspicuous example of one of the many ways in which The American Society of Mechanical Engineers aids the safety movement in this country. Safety is an engineering responsibility and has long been recognized as such by the A.S.M.E. Under the direction of its Standing Committee on Safety the Society has organized numerous safety committees, each concerned with the design, construction, or operation of some type of structure or machine. Moreover, the Society is officially represented on numerous other committees concerned with safety, and its public meetings and publications afford opportunities for papers and discussions devoted to the cause of safety.

In the current issue, for example, the first of a series of bulletins dealing with safety in elevators and related devices appears. Other bulletins of this series will follow. Thus the Society, in the course of its regular procedures, is actively engaged in the great campaign of reducing accidents and the tremendous loss in lives, human health and happiness, and material wealth that is such a reproach to modern civilization.

Democracy or Feudalism?

AN ENLIGHTENING article, "Union Management Co-operation: A Psychological Analysis," by Irving Knickerbocker and Douglas McGregor, of M.I.T., in the November issue of *Personnel*, directs notice to some features of the union-management production-drive committees which W.P.B. has been fostering throughout the nation. Emphasis is laid on broad psychological principles that are involved in the progress that management-labor relationships undergo from the initial stages of conflict to the final stage of co-operation. Running throughout the entire discussion of the factors involved in the subject presented is the common thread of mutual understanding on the part of the participants in the union-management relationship. "Only when this understanding is present," the authors say, "is it possible for growth to occur."

The fact-minded, logical engineer is likely to have little patience with psychology until he gives the subject some serious thought. More than once in these pages reference has been made to the dictum of a wise man that it is not enough to be right– one must be persuasive. The following quotation from the article by Knickerbocker and McGregor already mentioned sums up the case for "psychology:" "Union-Management meetings," they say, "are often carried on in an atmosphere of 'being logical' or 'sticking to the hard facts.' When this atmosphere exists, a barrier is raised against the expression of feelings and emotions. The man who insists on logic and facts will certainly fail to get 'out on the table' the nonlogical opinions and feelings which are important to real understanding. Co-operation under these circumstances is an impossibility."

It is easy to become enthusiastic over the possibility that in our industrialized society co-operation may supplant conflict, that the lion of management may lie down with the lamb of labor, or vice-versa, as one's interests may dictate. Industrial peace would go a long way toward making a better and a more livable world of men working together in harmonious purpose based on mutual confidence for mutually interdependent ends. Perhaps, however, there would still be abuses to correct, as suggested by a writer in the London *Economist*.

In an article on Ernest Bevin, the British labor leader, under the delightful title, "The Importance of Being Ernest," the idea of co-operation is carried one step further. "Mr. Bevin," it says, "believes that his objects can be obtained by co-operation between employers and employed: 'Industrial negotiating machinery (quoting Bevin) has produced the beginnings of an industrial democracy which will, as time goes on, probably take on new and more important functions.'

"He (Bevin) believes as much as any industrial feudatory on the employers' side in industrial self-government.'" Quoting Bevin again: "'We have promoted on both sides of industry a policy of self-government in industry. There has been a change-over to what I think holds very great potentialities, namely, negotiations of a more representative character than the old method of bargaining before the war. . . . Our aim has been to allow the collective-bargaining machinery to act as a sort of trustee on behalf of the State. . . .'

"This is not the voice of a Parliament man," the *Economist* commented, "nor of a State Socialist. There is something ominous about the readiness of producers of all kinds, men as well as masters, to band with one another to secure corporate autonomy. In the next era of politics—as indeed, at bottom, in the last—the tussle will be between, not capital and labor, but producers and the community. And the trade-union leaders are more likely to side in specific matters with the F.B.I. (British industrialists, not J. Edgar Hoover's organization!) than with the general public. True, Mr. Bevin believes that the trade-union movement which 'has now become an integral part of the State' will become the dominant partner. But the Industrial Socialism which he has evolved from his experience of collective bargaining is closer to the New Feudalism of the protective and restrictive thirties than to Liberal Democracy."

This is indeed something to watch.

The text pages of this issue have been reduced and some usual features have been omitted in order to meet the W.P.B. Limitation Order L-244 which restricts magazines to 90 per cent of the paper used in 1942.

WAR PRODUCTION IN 1943

By L. R. BOULWARE

ASSISTANT TO WILLIAM L. BATT, VICE-CHAIRMAN, WAR PRODUCTION BOARD

IT IS particularly fitting that we start the new year with the kind of meeting we have had here today. It has been devoted to the exchange of practical ideas and actual experiences. It is a part of a nation-wide effort to exhaust the possibilities of accomplishing 1943's tremendously increased production goal with the ultimate economy in men, materials, and equipment.

Nothing can be as important as reaching that production goal and doing so with the greatest possible economy. For 1943 promises to be the most decisive year not only in our own history but in the whole age-long struggle of men to be free.

Why is this year so important? Because time is no longer on our side. Our troops are now at or near the theaters where the major fighting is to take place from here on. Every day means that more of them will be lost, and more of their comrades will be lost in the transport of supplies to them and in their own replacements. Every extra day now, too, gives the Axis time to reorganize and bring into war production the conquered territories—Hitler, agricultural and industrial Europe—Japan, the fabulously rich captive regions of the Pacific. Every day, too, gives Germany time to organize the defense of Southern Europe and make its taking more costly. Every day that the stubborn defense of the outer islands continues to result in such a slow withdrawal gives Japan time to strengthen the home defenses and to delay and make more expensive the final victory to which every American has looked forward so fervently since Pearl Harbor.

What is the 1943 production goal? This year we must produce $180 billion of goods and services, $100 billion of which is for war. That's 56 per cent for war alone; more than we ever produced for *all* purposes in any year except the one just closed.

How can we grasp the unprecedented size of such an undertaking? Perhaps a comparison or two will help.

We will produce almost twice as much steel as in 1939 and more than three times as much alloy, and with only a slightly increased plant measured in percentage.

We must transport on our railroads twice the freight we did in the boom year of 1929 and must do it with substantially the same rolling stock. We have *less* rolling stock than we had in 1918, and the freight to be carried will be $2^1/_2$ times as much.

It is public knowledge that we will build in the neighborhood of 100,000 airplanes in 1943. Due to their size these are equal to something like 200,000 of the kind we are in the habit of thinking about, unless our information is extremely up to date. There is no basis of comparison for the fabulous amounts of aluminum required. Figures on the man-hours of utmost skill put on the varied and intricate instruments would be absolutely astronomical. The motors of this year's production of planes, however, will give an indication of the size of the forces with which we are dealing. The power developed by these motors is 15 times that of all the ships in service in the U. S. Navy. It is equal to $1^1/_2$ times the power of all the public and private electric generating plants in the world.

All our war needs are in just such gargantuan proportions. Let's look at one more, however, and that's shipping. We are apparently destined to fight this war 3000 to 10,000 miles from home. For that we can in many ways be truly thankful. Yet this blessing brings with it a tremendous task in sea transport and the protection of that transport. It is no secret that the enemy's agression has been brought up short and that the Axis is now on the defensive to a greater or lesser degree in all theaters except that in which the submarine operates. To provide the means for the transport and supply of our forces abroad, to protect that movement, and to replace the ships lost is the herculean job of shipbuilding we are undertaking this year. In 1942, a volume of ship construction was accomplished that amazed us all, as you know. And yet in 1943 we are to complete between two and three times as much tonnage as last year. This 1943 construction will equal almost half of all the ships now afloat. To realize this goal in cargo and naval vessels will be to break the real remaining bottleneck of the war and forge the final link in the equipment needed to destroy those who menace our world.

In the midst of this new concentration on planes and ships we shall sometimes hear of plants built for tanks and guns and ammunition not operating at capacity. This is not necessarily the result of bad planning or bad management. It is the natural by-product of the shift in the fortunes of war and in the relative importance of various weapons as fronts change. There will yet be many other difficulties of balance and adjustment during the tough bitter struggle ahead. We should not let them discourage us or destroy our confidence, but rather we must take them as occasions for intensifying our determination.

These great programs of which I have spoken, along with all the others, break down into individual duties for each of us. What is each of us to do in our daily work in connection with the orders that come to our plants?

First is to practice orthodox scheduling. The balancing of the over-all programs and the central scheduling in Washington are going to make scheduling at individual plants much easier from here on. But the final effectiveness of the over-all scheduling is going to depend on the faithfulness with which the individual company insists on information from its customers as to the really required delivery dates and then insists on its receipts from its own vendors being only as early as necessary to meet such a realistic completion schedule.

The next is to avoid bottleneck materials and bottleneck vendors. We must seek all possible substitutes and use all diligence in seeking materials from existing stocks. We did not get full benefit from our increases in productive capacity last year because of the tendency to ship and accept some materials and components faster than required by the availability of related items. This resulted in unbalanced inventories, which in turn give us now the opportunity to get completions out of proportion to productive capacity, if we can direct to the bottlenecks the tonnage that would otherwise go to needlessly forward items.

Further in regard to bottleneck vendors, we should seek every possible alternate producer and prepare to educate and make effective such new sources. Only by utilizing the productive capacity of the plants now being relieved of their civilian output can our 1943 production goals be met. We cannot divert materials from actual instruments of war to the making of new manufacturing equipment this year, and we

An address delivered at the War Production Conference, Hotel Pennsylvania, New York, N. Y., Jan. 7, 1943, sponsored by Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and other engineering societies.

could not wait for its completion, even though we could spare the materials. Let's keep in mind that this is a subcontracting war, and our success will depend in large measure on how effective at subcontracting we become.

In the case of the bottleneck plant itself, its management should put on an intensive campaign to see that it operates at 168 hours a week. If materials are the trouble, the case should be pursued clear through to the point where the relative urgency of the product in question as compared with others requiring the same material can be competently considered. If any of you can't find out where to go about a thing of this kind, write or phone me and I'll try to find out for you. On the other hand, if the trouble is manpower, there are known measures and agencies that can be used, and there's always one's own ingenuity in simplification and training. If the trouble is machine tools, the W.P.B. field offices should be called on for locating idle tool capacity. They do a marvelous job.

The next obligation is to practice every possible economy in transportation, fuel, light, power, supplies, and communication. These are all nation-wide bottlenecks.

There is the final obligation of the individual, be he worker or manager. It is to use the last ounce of ingenuity and intensity and self-sacrifice to see that he exhausts every possibility of making the most from the least—in this year of war-production needs of such unprecedented size and urgency.

But how is it going? We will continue to be at a disadvantage in the length of the sea routes to the various fronts. We *have* been at a tremendous disadvantage, of course, in the face of the huge reserves of implements of war our enemies piled up in preparation for this war. These reserves are now being slowly exhausted or matched by our production and transport.

In addition, our production in 1943 will, in much greater proportion than in 1942, be available for actual fighting purposes and should have a much more telling effect. Expansion of plants and tools took 20 per cent of the steel last year; this year it should take less than half that diversion. Vast quantities of materials were necessary last year for equipment and training at home; this will not be needed in 1943. Then we had to fill the pipe lines to the various fronts, and that's now largely done. Finally, we are on the offensive and, as everyone knows, that means selection of where and when we fight, the consequent concentration increasing greatly the economy and effectiveness in the employment of implements and supplies of war. Despite the long bitter struggle yet ahead, there can be but one outcome now, if only we measure up to the goals of which we have begun to show ourselves capable and determined to reach.

I believe we will be better sustained in our determination to exercise that utmost in ingenuity and put forth that totality of effort, if we will only realize that we can force from this awful experience a double benefit. First, we must put down the menace to freedom and decency, of course. That is the primary consideration until victory.

But there is a second consideration that should have a place in our thoughts and should give us added inspiration and determination. It is the fact that with all our grumbling as to sacrifices, we shall support ourselves this year and enjoy luxuries and pleasures in addition, all on a scale never equaled even in peacetime by the standard of living of any other people on earth. *And yet it will take only 44 per cent of our effort.*

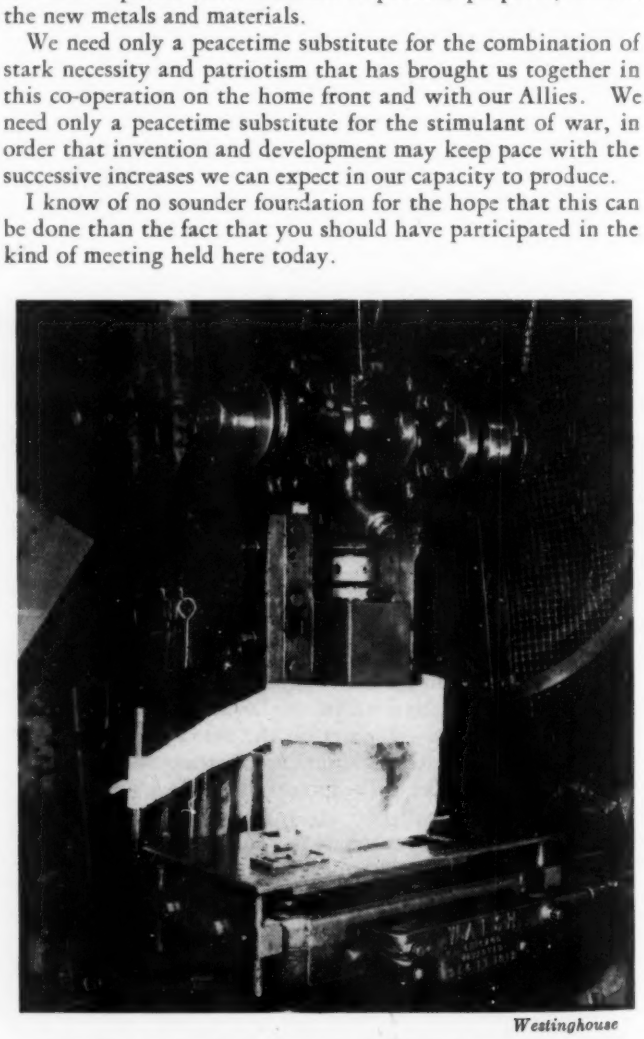
I was in Germany in the summer of 1939 within two weeks of the outbreak of this war. The people were already rationed down to potatoes and herring, one coat, and two pairs of pants. Their pleasures consisted of weak beer, propaganda movies, and Sunday picnics on foot. Yet they figured at that time that their subsistence and few pleasures took 50 per cent of the production. With our natural resources, our mechanization in the consumer industries, and our present production tempo, we could furnish ourselves their kind of a standard of living with around 25 to 30 per cent of our productive effort.

But think what even our present 44 per cent implies! Out of every hundred workers there are 44 who support the whole 100, and there are 56 who are doing war work. One day those 56 are going to be free to produce things or perform services that do not concern necessities but make solely for a richer life and a better world. We have been investing a part of their effort during wartime in plants and tools and scientific processes that can be turned to peacetime use. And we have been finding ways to salvage and train and make useful almost everyone above 'teen age who is not in a hospital. We have reconciled ourselves to, and mastered a new technique in, co-operation among competitors, between government and business, between management and labor, between Americans and British, Russians and Chinese. A new standard of values has stimulated us to a whole new level of invention and development and production accomplishment to which former peacetime incentives have failed to actuate us.

Let's resolve that this war is going to be made to pay us a dividend beyond merely the regaining of peace. Let's resolve that all these vast new factories will run; that these millions of freshly trained and inspired warworkers will have really useful peacetime jobs, that these sensational but horrible inventions of the war period will be turned to peaceful purposes, as will the new metals and materials.

We need only a peacetime substitute for the combination of stark necessity and patriotism that has brought us together in this co-operation on the home front and with our Allies. We need only a peacetime substitute for the stimulant of war, in order that invention and development may keep pace with the successive increases we can expect in our capacity to produce.

I know of no sounder foundation for the hope that this can be done than the fact that you should have participated in the kind of meeting held here today.



Westinghouse

ADJUSTABLE FLEXIBLE-GLASS PANELED GUARDS PROTECT PUNCH-PRESS OPERATOR'S HANDS

"TREMENDOUS TRIFLES"

Of the Army Ordnance Department

By THORNTON LEWIS

DEPUTY CHIEF, PRODUCTION SERVICE BRANCH, ORDNANCE DEPT.

IN THIS war Army Ordnance has had to assume a responsibility for the production of war materials that has required the Department to grow almost overnight into a business which is several times larger than any in the world. Proof of this is the fact that its requirement is 70 per cent of all the alloy steel produced in this country.

But tonnage alone, or even the staggering quantities of seven to eight thousand items which must be procured, does not paint the true picture of this business enterprise. This huge business has developed from a comparatively small peacetime business, with peacetime requirements and peacetime budgets, to its present gigantic size in a very short space of time. Two years ago Ordnance production was only a trickle, in December, 1941, it amounted to less than three hundred million per month, while now it is over a billion dollars a month. It has more than tripled in less than a year. The problems faced involve considerably more than creating an organization and awarding multiple contracts.

Getting an all-out global war under way and, at the same time, furnishing critical materials to all our allies, is far beyond the scope of any supply program previously planned or visioned.

When the quantities of weapons and defenses are suddenly increased beyond proportions ever dreamed of, all facilities for their production become inadequate. This is a key to many of our machine bottlenecks.

Choosing an ideal peacetime material out of which to make a part may also create a wartime bottleneck, particularly if our supplies, or part of them, are cut off by enemy conquest. This is a key to some of our material bottlenecks.

Other bottlenecks are caused by new developments of our own or those revealed by enemy action, and for these, unpredictable production facilities and materials are then required.

And there you have our problem. We were not only plunged into war with its immediate demand for production and more production, but we were plunged into the greatest redesign and substitution program that industry has ever seen or dreamed of.

The essence of war is competition and all-out war is a competition to see who can survive. The competition in the production phases of this war is an exact counterpart of the competition of business in which, year after year, individuals and entire industries have had to find new materials, create new designs, and devise new methods in order to survive.

The Ordnance Department is meeting this competition by going over designs and seeking improvements constantly. The motorcar industry required about 25 years to perfect its designs in mass production. Ordnance is trying to do the job in one or two years. Ordnance has 600 end products; the automobile manufacturers had only a dozen at most.

Ordnance cannot do the job alone, and the bulk of the problem rests with the engineers of industry who, in number and experience, are a reservoir of brain power and ingenuity equaled nowhere else in the world.

Contributed by the Production Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 30-Dec. 4, 1942, of The American Society of Mechanical Engineers.

SUGGESTIONS FOR DESIGN CHANGES SOLICITED

Ordnance is anxious to receive suggestions for design changes from all sources and is geared to place quick approval on the good ones. In this connection, it should be remembered that quality and workmanship of all equipment given to our soldiers must be of the highest order to assure safety to our men and reliable performance in the field. It is, therefore, imperative that proposed changes in design be brought to the attention of the proper authorities, who consider the suggested designs from all angles, proof and test when necessary, and, if the design is found equal or superior to the existing one, approve it promptly. No design changes will be approved until its performance and chacteristics are positively known.

It can be said that Ordnance engineers are keenly alert to any potential improvements, are progressive in their thinking, and come to a decision as rapidly as is possible with the size of the available engineering staffs.

One of the purposes of this paper is to request specifically the help of the engineers of industry in this important and necessary work. We ask that they contribute not only design improvements but that they see to it that such improvements are of the right character and are properly presented. The character of suggestions to be submitted is not necessarily limited, but Ordnance desires that those suggestions which save material be the ones upon which engineers concentrate. Suggestions relating to other savings, while valuable, usually can best be effected by plant management and need no scrutiny or approval of Ordnance engineers.

The following is the process by which contributions may be made most helpful:

What to do. It is not necessary to tell engineers that, in general, ordnance matériel has been largely manufactured from alloy steels, brass, aluminum, and the like, on and by machine tools that are difficult and costly to build. These materials and tools of production are critical today because the quantity required is so very great. Our conversion campaign in the Ordnance Department is to redesign so as to substitute less critical materials and tools for those that are scarce. Carbon steels are more plentiful than alloy steels, brass, or aluminum. Foundries for making gray-iron or malleable castings and presses for forming or extruding metals are plentiful. Plastics, glass, and plywoods may be had in abundance. This then is our task—to recast the designs and processes so as to find acceptable substitutes by using in new ways the machines and materials that may be obtained without limit and thus ease the burden on the materials and machines for which there are no substitutes.

Where to submit suggestions. Address Major General T. J. Hayes, Ordnance Department, U. S. Army, Pentagon Building, Washington, D. C., or the "Suggestion Unit" of any of our thirteen Ordnance District Offices.

What happens to suggestions or redesigns submitted.

1 All suggestions are recorded and acknowledged.

2 They are referred to a special corps of design engineers, metallurgists, and tool designers, whose sole job it is to study

the ideas and suggestions received and reduce them to definite form, inproving upon them, if possible.

3 These specialists confer with the experienced ordnance engineers in the several branches of the Ordnance Department to adapt the new designs to the known needs. Here, the making of samples for tests or proofing is decided upon—or the suggestion is rejected for good and sufficient reasons.

4 The sender of the suggestion is advised that his idea has been adopted or that his suggestion cannot be used, and he is told why.

The more definite the suggestion, the more valuable it is, and the more quickly it can be acted upon. While special units have been set up in each of the Ordnance Districts to receive and work upon suggestions and new designs, all are cleared through one central place in order to bring together all the ideas bearing upon any one component or part. Designs requiring development work may later be redistributed to any of the several districts, for the job is so vast it cannot well be handled in one place; also, work in the districts can more easily receive the close co-operation of industry.

But if one could examine the record, he would see that the job is being done. It would take volumes to record it in detail and a greater number to record what remains to be done.

A CRATE IS REDESIGNED

The story of accomplishment of industry and Ordnance to date should be told and its problems outlined in order that industry may be in a still better position to contribute to their solution.

Here is the way that co-operation has worked. One of the ordnance engineers felt that the crates for bomb fins required so much steel that an effort should be made to reduce it. So a study was made and a potential new design was sketched out. Five manufacturers were called in and the problem was laid before them. In a short time each of these manufacturers came back with a solution. The best one was picked, this new design saving 45 per cent of the steel formerly used. It is now in production; 400 carloads of steel are being saved. By using a clip on the crate corners made of a steel stamping instead of a threaded lock nut, the cost was reduced and the amount of steel cut 88 per cent. This saved 8.7 carloads of steel on one ordnance contract.

Not satisfied with this saving, further study was undertaken, and the fin design has now been so changed that the fin itself folds up, and ten to fifteen fins can be put into approximately the same size crate that held one fin, so that not more than one tenth of the steel will be required to crate bomb fins in the future. This reduces by at least 90 per cent the shipping space and the storage space required in the field at or adjacent to the air fields from which our bombers take off.

HOW CRITICAL MATERIALS ARE SAVED

Another purpose of this paper is to show typical examples of ways and means of saving critical materials, unburdening overloaded machine tools, and gaining speed of production, in the firm belief that from the engineering profession will come the new ideas and processes that are needed if we are to bring this war to an early and successful conclusion.

Here are just a few examples of ideas and designs that have been of tremendous help. These are some of the "Tremendous Trifles."

Applied Arts Corporation of Grand Rapids submitted a suggestion on the M4 tank turret ball retainer which allows a steel stamping to replace a part made from a brass bar. This saves 200 tons of brass.

The Reid Products Division of the Standard Products Company, Cleveland, worked out a lock nut for a bomb fin as a stamping instead of a forging. This saved enough steel to make 11,500 Garand rifles, and also 100,000 machine-tool-hours.

Another suggestion that will save thousands of tons of steel came from the Alton Box Board Company, Alton, Ill. This one concerned shipping bands for bombs, the proposal being to make them of paper instead of steel.

Changing a gasoline-tank filler cap and strainer from a machined brass casting to a low-carbon-steel stamping for certain motor vehicles will save more than 400,000 lb of brass in the next year.

A howitzer breech and muzzle hoop, formerly forgings with lifting lugs, now tubular rolled stampings with welded lugs, saves 61 per cent of the steel previously used.

A booster for high-explosive shells has been converted from brass bar stock requiring automatic screw machines to a steel stamping; 83,000 tons of brass will be saved in 1943 when this change has become effective.

No small saving of any critical metal should be overlooked. One of our contractors suggested making a cover and link of malleable iron. This was being made of bronze. Only a few of these gun carriages were to be made, so the change on the cover saved only 348 lb and on the link 1740 lb. Together over 1 ton of bronze was saved.

Cartridge cases for large and small artillery are being shifted to steel instead of brass because American industry has set itself to the task of conserving brass.

SAVING THE ALLOYS

A major bottleneck in our war production, of course, is our supply of nickel, chromium, vanadium, molybdenum, manganese, etc. needed for high-alloy steels. In peacetime, steels using these metals amounted to only about 7 per cent of our total steel requirements. In this war the percentage has climbed to 20 per cent of the total. In addition is the fact that, with the exception of molybdenum, we are dependent upon imports for much of our supply.

Therefore it can be easily understood why every effort is being made to devise ways and means of doing without as much of these alloying metals as possible. Here are a few examples of successes along this line:

A gun barrel was made by the centrifugal-casting method instead of forging. This will save 360 tons of critical nickel and 6 tons of critical vanadium per month.

By the improved heat-treating processes, armor-plate specifications have been changed to save 520 tons of nickel, 100 tons of chromium, and 16 tons of molybdenum every month. And, by the same kind of process, we approach comparable savings in making armor-piercing projectiles.

Even that famous "persuader"—the bayonet—has come in for redesign and heat-treatment which make it a better weapon made from less critical steel.

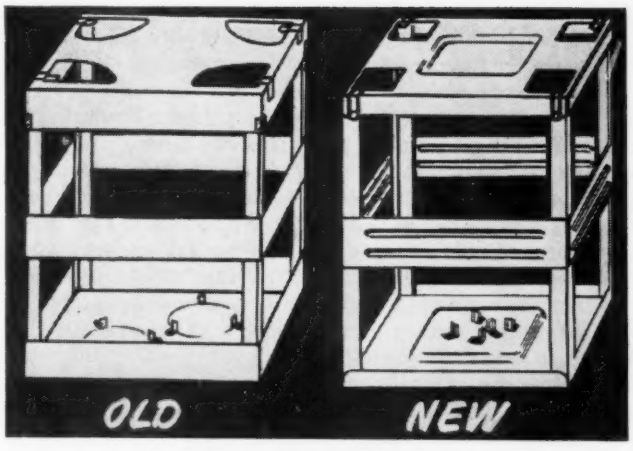
Low-carbon steel, coated or plated, is saving scarce stainless steel. Castings which are nearer to the finished contour and dimensions than forgings are saving machine-hours needed elsewhere, as well as critical ferroalloys.

INDUSTRY CO-OPERATES WITH ORDNANCE DEPARTMENT

To indicate the type of co-operation which the Ordnance Department has received from industry, two instances are cited; many others equally meritorious could be mentioned.

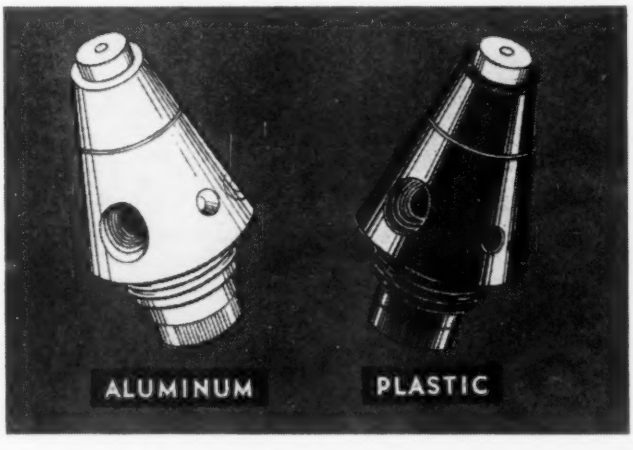
The first is the case of the Frigidaire and a-c spark-plug divisions of the General Motors Corporation, manufacturing an aircraft machine gun. By ingenuity in redesigning parts and tools and by making substitutions for critical materials, the following has been achieved:

The number of man-hours required to produce one gun has been reduced 49 per cent. The raw material used is 100 lb less

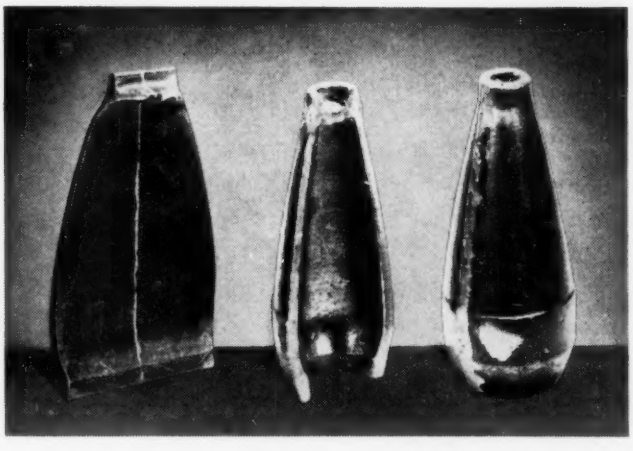


Redesign of bomb fin crate with certain parts embossed for greater strength permits use of lighter-gage metal and saves more than 400 carloads of steel

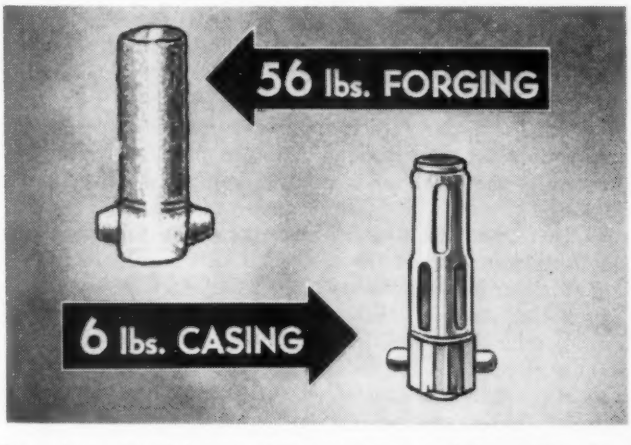
Booster formerly machined from 3-lb steel bar now made from pressed steel on stamping machines and on one and one half million adapters pressed from steel



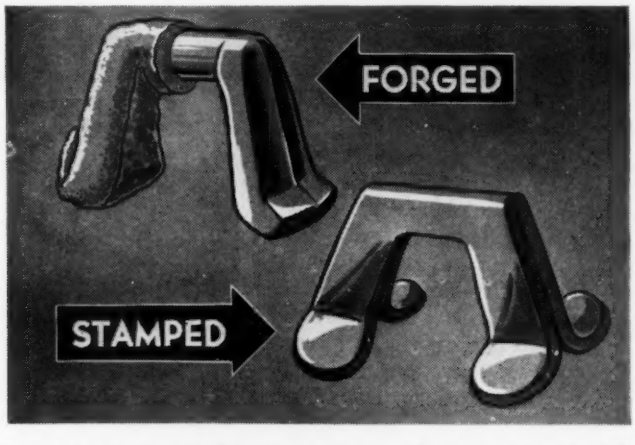
Substituting plastic for aluminum in fuse body saves 1 lb of aluminum in every fuse of this type, enough on present procurement for 180 four-motored bombers



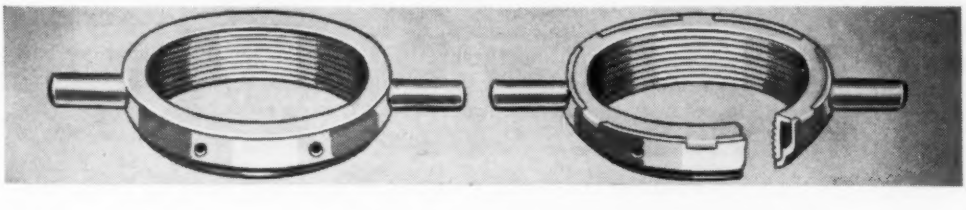
New method of manufacturing 81-mm mortar shell saves 12,000,000 lb of steel and 750,000 machine-hours on present procurement; section is rolled out, blanked, and drawn and identical pieces welded and machined



Formerly machined down to 6 lb, casing now made by welding *drawn* sleeve to forged base, saving 42 lb of steel scrap, 3 standard man-hours, and $18 to $20 a gun



Forged lug from pressed steel and mass-produced on otherwise idle stamping machines. On first 100,000 lugs, 17,000 lb steel and 8000 machine-tool hours were saved



Threaded stampings instead of machine and threaded forgings saved 100,000 machine-tool hours on the manufacture of 200,000 of these fin lock nuts. It also saved $283,000 and enough steel for 11,500 Garand rifles

per gun. A total of 38 different steels was originally required to produce this gun. Now 18 are used, and the amount of alloys, such as nickel and chromium, is greatly reduced. The cost to the Government has been cut 45 per cent. Production of these as early as last May was 47 per cent ahead of schedule.

The other case is the National Cash Register Company, which is making many items of Ordnance for both the Army and the Navy, on which savings of similar magnitude have been made. On only one small item, a fuse, the following was accomplished:

Eighteen tons of aluminum and 155 tons of brass were saved per month. Seventeen old punch presses were used replacing one broach, two four-spindle drill presses, and five automatic screw machines, the latter being critical machines vitally needed for other work.

GAGES MADE OF GLASS

One of the most recent ideas developed will perhaps astound as well as interest all engineers. From the beginning of precision manufacturing, close limits have required gages made of fine steels. These gages have to be oiled or otherwise protected to prevent rust; they have to be carefully handled to protect their surfaces from injury; they have to be expertly hardened to preserve these true surfaces. Many hundreds of thousands of gages are required to supply manufacturers and Government inspectors in this production war we are fighting. We have had under development and are now beginning to use gages made of glass. The following types of glass gages now may be used to replace steel gages:

Plug, go and no-go, $^1/_4$ in. diam and over, single and double end.
Ring gages, go and no-go, single and twin.
Combination ring and snap gages.
Snap gages of the fixed type.
Profile and position gages.

Only a small number of glass gages have been made and placed in service, but the latest opinion is that 50 per cent of the gages now made of steel may be replaced with glass gages.

So far these glass gages have proved equal to, and, in many respects, superior to, those made of steel. Here are ten advantages of glass gages over steel gages:

1 Many greasings and degreasings are eliminated, since no question of rust is involved.

2 Scratches on glass do not raise a burr or change the effective size of the gage.

3 Glass gages are easier to handle as they are lighter than steel.

4 The thermal conductivity of glass is less than steel and heat transmitted from the hands of the inspector will not affect the gaging dimensions.

5 In some cases, visibility in inspection is afforded.

6 Perspiration on the hands of the inspector has no corrosive effect on a glass gage. It is not easily broken.

7 When the component is near the size of the gage, there is less tendency for it to seize or gall in or on the gage.

8 Glass appears to have abrasive-resisting qualities equal to or better than steel in many gaging applications.

9 An incidental advantage is that glass will perhaps teach the user to have respect for gages when handling them.

10 Finally, and most important at this time, is the saving of tool steels. Not so important, but quite worth while, is the fact that after the molds for glass gages are made, the cost of glass gages is about one half that of steel gages.

Another interesting development is making the handles of steel gages of colored transparent plastics. This also makes possible the quick recognition of the gage desired by its color. By leaving a hollow cavity inside the handle, the name and designation of the gage on a printed slip may be inserted, thus eliminating engraving this information on steel.

It may be of interest to know whether, so far, many valuable suggestions have been received and used. In the 2 months that our conversion program has been under way (this up to November 3, 1942), more than 1100 suggestions have been received. Of these about one half, while valuable, were of general character. The other half were definite and pertained to a particular component of ordnance matériel. Of the definite ones which have been acted upon, more than 60 per cent have been accepted and the others rejected for good reasons. It will be agreed that this indicates (1) that a great proportion of intelligent people have been sending in suggestions, and (2) that Ordnance engineers have shown an "open-mindedness" when it came to changing original designs and accepting ideas from the industrial worker and engineer.

CHANGES MUST STILL BE MADE

In conclusion, there are three main points to be made, and it is hoped that each of them will be accepted with the utmost seriousness:

1 The specifications, designs, and manufacturing methods used in producing thousands of parts and complete units of our war machine must yet be changed to save critical materials, relieve overburdened tools, and increase production. It is not necessary to recite the exact facts of our raw-material supplies and our machine bottlenecks, but it should be said that if our specifications were the same today as they were 2 years ago, we would already have reached our production ceiling for certain items. Thanks to hard work, ingenuity, and inventive genius, many of them have been changed and we have not yet reached our production ceiling.

Further, if our specifications, in 1943, are the same as they are at present, we will have reached our production ceiling, and that ceiling is not high enough to get this job done on time. But the specifications will not read that way in 1943, and we will have a still higher ceiling to attain.

2 Our tremendous organization has been whipped into such shape that all branches of industry and ordnance can, with the least possible effort, make their contributions effective.

In Washington and in each of the 13 Ordnance Districts are units established to clear the channels to allow the ideas and the needs to meet on productive ground. Every idea received is recorded, acknowledged, expedited, and given the attention it deserves.

Do not get discouraged if approval of a specific design suggestion does not come through by return mail, for extreme care is necessary to prove the soundness of individual ideas and suggestions.

3 There is so much yet left to be done that every individual must take some part of the problem as his personal responsibility and put his brain to work on it.

In closing may we ask all members of the engineering profession, their associates, and suppliers to do just one thing; examine the part or unit in our war production that each contacts in his daily work and devise ways and means of making it better, faster, cheaper, of less critical materials, on less critical machines.

It is going to take just that to get this job done.

As I read history, wherever an existing social order has been overthrown, it has been because the top strata of that society did not measure up to its responsibility.

In this country, the top is reached not by birth or position, but through competition and achievement. Let it not be said of us that our democratic institutions perished because *we*, the engineers of America, failed to do *our* duty.

Problems in the USE *of* PLYWOOD *in* AIRPLANE CONSTRUCTION

By ALEXANDER KLEMIN

GUGGENHEIM RESEARCH PROFESSOR, SCHOOL OF AERONAUTICS, NEW YORK UNIVERSITY

SO MANY reviews of the uses and possibilities of plywood in aircraft construction have appeared recently that it is no longer necessary to stress its advantages or to make a plea for its extensive use in our aircraft-production problem. The present paper does not propose to add to the number of such reviews. The paper takes for granted that airplane construction in plywood is fully accepted and recognized and undertakes the informal discussion of the difficulties and problems of this art. The study of these problems and their solution whenever possible constitute the objectives of the A.S.M.E. Research Committee on Plywood in Aircraft Construction, for which the author is acting as chairman.

The committee, selected under the joint auspices of the Aviation and Wood Industries Divisions of The American Society of Mechanical Engineers, is well qualified for the task, approaches the subject from many points of view, and includes:

Dr. O. H. Basquin, consulting engineer, Haskelite Manufacturing Corporation.

Arthur C. Fegel, Western Electric Company; secretary, A.S.M.E. Wood Industries division.

Fred Flader, chief engineer, airplane division, Curtiss-Wright Aircraft Corporation.

E. Sigurd Johnson, war production division, H. J. Heinz Company.

Dr. G. M. Kline, technical editor, *Modern Plastics*.

A. W. Loerke, chief engineer, Duramold division, Fairchild Engine & Airplane Corporation.

Dr. Robert J. Nebesar, chief engineer, Universal Moulded Products Corporation.

George B. Parsons, assistant chief engineer, Duramold division, Fairchild Engine & Airplane Corporation.

Thomas D. Perry, Resinous Products and Chemical Company; chairman, A.S.M.E. Wood Industries Division.

Herbert V. Thaden, president, Thaden Engineering Corporation.

O. W. Timm, president, Timm Aircraft Corporation.

Orvil S. Tuttle, chief engineer, U. S. Plywood Corporation.

E. L. Vidal, president, Vidal Research Corporation.

Dr. Alexander Klemin, Guggenheim Research Professor, New York University; chairman of committee.

The work of the committee has been tentatively classified under the following self-explanatory headings:

1 Aircraft Veneer and Plywood Manufacture.
2 Selection, Inspection, Availability of Materials, and Specifications.
3 Adhesives and Their Application.
4 Special Fabrication Processes.
5 Plywood Components of the Airplane, Fittings, and Connections.
6 Airplane Construction and Assembly in Relation to Plywood.
7 Testing of Plywood and Plywood Parts.
8 Strength Properties of Plywood.
9 Structural Analysis.
10 Bibliography.

The committee does not propose to undertake any experimental work as a committee but to write its report on the basis of careful study of all available publications; and on the pooled knowledge, scientific, technical, and trade practice of its members. The present informal statement indicates the scope of the questions which the chairman is placing before the members of the committee. The list of headings is neither exhaustive nor extensive but is suggestive and calculated to elicit other queries. It also permits an invitation to be extended to all others interested in aircraft plywood to co-operate in an investigation whose findings will be used to the general benefit of American aviation.

AIRCRAFT VENEER AND PLYWOOD MANUFACTURE

In recent years the manufacture of veneer and plywood has advanced to such an extent that in basic principle, methods of manufacture scarcely need improvement. In practice, the airplane constructor may have some cause to complain of the product he receives, and these complaints will invariably relate to variations in the manufacture of the veneer or the plywood panel as a whole. The committee does not propose to study the matter of plywood manufacture but merely wishes to draw attention to difficulties as the airplane constructor is apt to see them.

(*a*) Better selection and softening of logs seem to be necessary at times, because (after apparently careful cutting) a $^{3}/_{16}$-in. ply may run off in thickness $\pm^{1}/_{32}$ in.

(*b*) There may be variation in density in the veneer of a single sheet of plywood, as a result of defects in the cutting process, or in the selection of logs, and density variation implies strength variations.

(*c*) The thickness of a plywood panel may vary so much that in gluing together eight $^{1}/_{8}$-in. plies to make up a 1-in. panel, it may be necessary to mill down a face ply. To make the two outer plies of the same wood is a palliative, but not a welcome one. Again, to make two outer plies of beech, let us say, so as to retain a hard-surface outer ply after milling down is an unsatisfactory expedient.

(*d*) The thickness of a panel and of its component veneers may remain uniform, but the grain may run wider apart at certain points with resultant loss of strength.

(*e*) Difficulties may arise in moisture control and in the selection of the primary wood.

When we consider the enormous increase in the demand for aircraft plywood in the war effort, we can readily understand how such defects have crept in. Closer inspection and the

Contributed jointly by the Aviation and Wood Industries Divisions and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of The American Society of Mechanical Engineers.

training of many additional inspectors seem indicated to increase the reliability of the product.

SELECTION, INSPECTION, AVAILABILITY OF MATERIALS, AND SPECIFICATIONS

For all those who have been long associated with the aviation industry, wood has come to mean spruce and plywood, a panel with spruce core and beech faces. Wood and plywood construction of airplanes has been revived of recent years because it replaces vital materials, such as aluminum or high-alloy steels. However, we now find that spruce itself is becoming a vital and scarce material, and that other woods for the cores of aircraft plywood have to be sought (faces do not constitute a difficulty because beech, ash, or mahogany are plentifully available). Will cores of poplar or fir be satisfactory, what sacrifice in strength properties do they entail, where can plywoods with such cores be obtained, and how should they be specified? These are again questions of a practical character requiring no recondite research, but to which definite answers are quickly needed.

We have already indicated the manufacturing difficulties of plywood, at least in so far as they appear to the aircraft constructors. Such airplane constructors purchasing from reputable plywood manufacturers on Army and Navy specifications cannot be quite certain of the strength characteristics of the plywood they are purchasing. In the purchase of metals, steel or aluminum, composition and metallurgical processes are so rigidly specified that the purchaser can rely upon the corresponding physical properties. In the purchase of plywood, the lack of uniformity in the manufacturing processes which we have previously discussed may result in disappointing differences in strength, even though plywood has been bought on a standard Army or Navy specification. One prosaic but very practical problem lies, therefore, in the framing of even more rigid and inflexible specifications than those at present offered by the government services. In such specifications, the question of allowable strength has to be defined much more precisely. To secure abrasive strength, we specify panels with beech or mahogany faces, but it does not appear that just calling for beech or mahogany secures a hard enough external surface. Nothing is said in the specifications as to how the face plies should behave under nailing, or under the effects o rain, or under the application of several coats of primer or paints. Moreover our specifications are quite vague as to tolerances. It would be quite impossible with an organic material such as wood to neglect tolerances or to call for exceedingly close tolerances, but some consideration of tolerances should be in every specification.

ADHESIVES AND THEIR APPLICATION

We have read in many papers and articles that modern synthetic-resin glues or adhesives are greatly superior to their predecessors of organic origin. So they are, and, if the manufacture of plywood from veneer is considered, synthetic resins of phenol formaldehyde in the hot-press process give satisfactory results and rapid production. But in aircraft assembly the use of cold-setting glues (casein or urea) is almost universal, and while processes at temperatures around 70 F are satisfactory, they are slow. Moreover, if the cold-setting glue (urea or casein) retains its adhesive properties during an appreciable period of time, say 24 hours, it may give unsatisfactory service thereafter. Casein glue, which is of animal origin and therefore subject to bacterial attack, can only be used on trainers and the like where frequent inspection may be taken for granted; it would not be tolerated on high-speed combat airplanes. Urea glues, being synthetic in origin, are proof against the growth of fungi, but it is doubtful whether urea-glue assembly can be relied upon to stand up indefinitely in extreme temperature variations, in the boiling-water test, or under the action of hot oil. Urea has crazing tendency and is not highly stable under extremes of temperature.

The trend seems to be away from both casein and urea glues for assembly work toward the entirely satisfactory phenolic resins. For assembly processes it would be highly desirable to have available low-temperature-setting phenolic resins. If a low-temperature-setting phenolic resin is not to be hoped for, then research must be concentrated on assembly with local heating of joints by some process which shall be satisfactory in strength and endurance and capable of application in the average airplane factory.

Even local-heating temperatures between 240 and 300 F may result in unpleasant working conditions in an aircraft plant. Melanin glue, which approaches the properties of phenolic resin, sets at 240 F. There is also a glue, manufactured by the Bakelite Corporation, which sets at about 240 F, which seems to be suitable for airplane-assembly work.

A number of local heating processes have been tried out with fair success. Thus, high-frequency alternating current may be used with a condenser formed by two metal plates, with the spar or other wood part constituting the dielectric medium in between. The rapidly alternating electric waves passing through the wood produce local heat of the required intensity. This high-frequency process is very promising but long research is needed to overcome the difficulties which have become apparent. It is important, of course, that the current should be applied in lines of flow of uniform density, and, where an object like a spar tapered in width from root to tip is to be glued together, it is difficult to maintain uniform current density. Where the wood is at its narrowest, there is danger of its being overheated or even burned. Corona losses and arcing over may occur. With expert electrical engineers on the job and sufficient care and calculation, difficulties can be overcome, and the process is quite worthy of practical research as an accelerating agent in plywood-airplane production. Another local heating process using electricity is the so-called strip-heating process, with an electrical resistance coil surrounding or boxing in the joint to be glued.

In spite of the promise shown by the electrical heating processes, the majority of airplane or airplane-part manufacturers seem to prefer the use of cold-setting glues for assembly purposes, or else to utilize hot presses for some proportion of the assembly work, even though the hot-press equipment may mean a very large investment. Enough has been said to indicate that a vast field of research is open in gluing of parts and assembly work.

Another question deserving of study is the bonding of plywood to metal, where a difficulty arises, because the two materials offer different resistance to the penetration of the adhesive, although this particular difficulty may perhaps be met by differential distribution of the glue. The use of a rubber-latex cement is not looked upon favorably because of the scarcity of rubber and the deterioration to which latex cements are subject and their lack of resistance to aromatic fuels. One or two synthetic adhesives have given promise when applied under pressure and aged at a fairly high temperature. Using vinalyte resins of the thermoplastic types appears to give good bonding characteristics at first, but there is subsequent creep to fear under marked temperature variations. Another difficulty lies in the fact that in actual service the moisture content of the wood changes, while the metal remains impervious to moisture. Some designers have expressed doubt as to the fatigue characteristics of a part or panel in which plywood is glued to metal.

The gluing of wood and metal together under pressure, with simultaneous or subsequent application of high temperatures,

may lead to another difficulty. The isotropic metal expands in two directions with equal coefficients of temperature. The nonisotropic plywood has varying coefficients of expansion. The result may be an internally stressed unbalanced panel which reduces its ability to take up stress subsequently. To obtain the best results and strong bonds in cementing wood to metal, great care has to be taken in cleaning the wood, spreading the cement, drying time, pressure, temperature, and curing. The operation of cementing wood to metal is likely to remain difficult and critical.

Starved glue joints between parts are at times attributed to the application of too little glue when in reality the moisture content of the plywood has become too low, or moisture and temperature conditions have been unfavorable during the assembly process. A pressing problem, therefore, is in the moisture and temperature control of the aircraft plant where plywood or wood parts are being assembled. The hot-gluing on assembly also constitutes a strong argument for plant air conditioning, if healthy working conditions are to be retained.

SPECIAL FABRICATION PROCESSES

By special fabrication processes, we really mean bag-molding processes of one species or another. Great advances have been made in this technique, in which thin strips of veneer are glued over a mold, with subsequent submission to pressure through a rubber bag in a steam-heated cylinder. These processes seem particularly well adapted to large parts or parts comprising sharp double curvatures. It has been claimed that such processes are of quite recent invention; in reality they are quite old in the woodworking art, and recent work has been more in the character of improvements over earlier processes. Remarkable claims have appeared and have been largely substantiated by recent construction and experience. Nevertheless a whole series of problems remain to be solved:

(*a*) Molds of wood appear to be quite satisfactory for short periods of use but have to be replaced by metal for longer runs. They are, on the whole, quite expensive and have the disadvantage in that, once built, they cannot be readily modified. Hence the use of the bag-molding process is not likely for airplane types which may have to be changed, following reports of service experience.

(*b*) For a large part, such as a fuselage, with compound curvatures, veneer has to be carefully tailored to the job, cut in thin strips, carefully laid by hand over the mold, considerable skill being involved. The heated cylinder takes up a good deal of room and involves a considerable investment. The "cooking" process following on the tailoring is astoundingly rapid, but the impression that bag molding gives the most rapid production possible is erroneous. Greater rapidity in the tailoring and other parts of the technique would be desirable.

(*c*) Because the tailoring process may involve a period of say twenty-four hours in a large and complicated part, the glue must be such that it can be applied cold and retain its adhesion properties for a long time. Glues that are most satisfactory during the fabrication process are apt to lose their strength in service under severe conditions of temperature exposure. Practical research is needed to make sure that the glue best fitted for the fabrication process will retain its strength indefinitely in service. This point alone explains the reluctance of Army and Navy Air Services to accept the construction for combat airplanes (although the service record and behavior under machine-gun fire of the British *Mosquito* bombers, which are built entirely of wood and plywood, may serve to remove this prejudice).

(*d*) The life of the rubber or synthetic-rubber bags employed in bag-molding operations is only fifty hours. A substitute material is urgently needed and is being sought.

PLYWOOD COMPONENTS OF THE AIRPLANE FITTINGS AND CONNECTIONS

We cannot go so far as to say that such components of the airplane as beams and ribs no longer offer any difficulty, but their design and construction are thoroughly well understood. There are, however, a number of practical points in the construction of an airplane which need experimental design and testing. Representative problems are:

(*a*) In aluminum construction, the almost classical formula now is to employ a thin sheet-metal covering, two or three spars or vertical webs, and to reinforce the skin with stringers or stiffeners. This practice has been carried into wood or plywood construction, in spite of the fact that the lighter plywood covering could have a much greater moment of inertia and local stiffness for the same weight per square foot, so that stiffeners might be dispensed with and wing or fuselage, or both, be converted into true monocoque or shell structures. A very attractive problem would consist in designing and testing true monocoque structures, which appear all the more promising because of the availability of such splendid molding processes.

(*b*) In the plywood wing with skin covering and two spars, let us say, which is a conventional type of construction, the outer panel is apt to be connected to the center panel through hinges and appropriate fittings. At such a time, considerable concentration of stress is apt to be encountered, a concentration of stress for which wood and plywood are not so well fitted by their allowable bearing stresses, and because high bearing stresses may lead to distortion even if there is no failure. It would be an interesting design problem to use compreg or other densified wood at such points both for flanges and webs, both for solid and veneered parts.

(*c*) In the same type of construction the skin, of course, takes up a part of the bending moment in tension on the lower surface and compression of the upper surface of the wing. The stringers act in a similar manner, and the skin also takes up shear, due to the torsion which is likely to be acting on the wing. A difficulty arises in transmitting stresses from stringers and skin indirectly to the hinge pins which so frequently carry the loads of the outer wing panel. The designer must decide whether he will require skin and stringers to be connected to an end bulkhead which will take up torsion and convert it into bending moment, or provide a metal box at the inner end of the wing, or resort to some other expedient.

(*d*) We have said that ribs and spars have become conventional in plywood construction, but it is not true that design problems relating to these parts have disappeared. For example, in the spars, which are so tempting to construct as box beams, weight is added because the flanges come too near the neutral axis. In the ribs, lightness of construction is secured by diagonal-web trussing and small gussets at each end of the diagonals connecting them to the cap strips. But the high strength-to-weight ratio of the ribs is secured at the expense of a multiplicity of parts, and difficult fitting of parts which militate against speedy production.

It will be seen that these questions are not those of profound research but belong to the province of the practical designer. Nevertheless, they merit solution and quicker solution than is offered by in-co-ordinated trial-and-error efforts in many drafting offices.

AIRPLANE CONSTRUCTION AND ASSEMBLY IN RELATION TO PLYWOOD

The assembly of a wood-construction airplane in some respects offers exactly the same problems as the assembly of a metal airplane; its fixtures are the same but jigging and connections are totally different in character. In metal aircraft, we use welding or riveting, while in the wood airplane, assembly is mostly a question of gluing and holding down ply-

wood over a wooden structure or form by nailing or nailing strips and gluing by the cold-gluing process previously discussed. Research here lies in the effort to accelerate assembly by the use of powerful presses and heat effects. Instead of slowly cold-gluing the upper surface skin of a stabilizer to its structure, much more rapid assembly of the stabilizer has been achieved by the use of a large and powerful hot press, by borrowing somewhat from the technique of drop forging, let us say. If a manufacturer is willing to jig or tool up, if not for the wing, then at least for the fixed or movable auxiliary surfaces, he will find it possible to realize astounding savings in time and expense. Of course there are two important difficulties; (1) the possibility that the workroom may become very hot and necessitate expensive air conditioning; (2) the very heavy initial investment. It would be an excellent part of the committee's activities to make both primary and secondary airplane contractors more jig-minded, to make them willing to invest a fair proportion of the value of a production contact in tooling or jigging-up, following the lead of our automobile manufacturers rather than the century-old practices of our piano manufacturers.

TESTING PLYWOOD AND PLYWOOD PARTS

Practice in the testing of plywood itself is fairly well standardized and requires no special consideration; where difficulties arise is in so testing plywood elements of an airplane that actual stress conditions are simulated, particularly combined stress conditions. Thus, the curved upper surface of a plywood-skin wing may be called upon to resist compression stresses due to bending, in combination with shear stresses due to torsion. We may perhaps simulate the compression stresses by tests of a curved panel in edge compression, and the shear by the torsion test of a plywood cylinder, but these two tests will not give information on the possible buckling or wrinkling which may occur under the combined stresses. Moreover, difficulties arise as to edge conditions and the like. So difficult does it appear to designers to simulate actual conditions in plywood elements that they very often prefer to test an entire wing panel, or a substantial portion of a wing panel. The drawback in testing a wing panel is that failures may occur in certain parts of the wing before information is gained on the strength of another element of the wing, although the latter information may be desired much more urgently. The pressing problem, or rather the pressing number of problems, in testing technique is to simulate complex load conditions for parts of the structure.

STRENGTH PROPERTIES OF PLYWOOD

The design of aircraft is largely in the hands of engineers, and engineers always use with reluctance any material regarding whose strength properties they are doubtful. This is a fact which those who sell plywood to aircraft companies would do well to bear in mind. Instead of endeavoring to sell their product on appearance and general characteristics, they would do well to be armed with adequate strength data. They would do well also to recognize that, in the construction of airplanes, the character of the stresses involved is not covered by just tension and compression. Wood and plywood may be in tension, compression, shear, bending, shear due to torsion, and under a combination of these stresses. Stresses may act in a number of directions for the same part, and the same part may in place be subjected predominantly to bending, in another to shear, as for example, the vertical web of a box beam. The available data even for solid wood are meager, and it is only a very few woods for which shear has been investigated. For plywood, the data are still more scarce, and the situation is complicated by the fact that instead of a small number of woods, we have an almost infinite number of possible veneer combinations to form plywood.

Another difficulty arises from the fact that, while the elastic theory of isotropic materials is well understood, the elastic theory of nonisotropic materials is less well understood and more complex, and the elastic theory of plywood is even more complex, because plywood involves the combination of a variety of nonisotropic materials. Even with isotropic materials, such as steel or aluminum, theoretical treatment of such problems as the failures of thin tubes under torsion by buckling becomes highly complex; and the resultant formulas difficult to reconcile with experimental results.

Plywood manufacturers have done some work along the foregoing lines, but without any degree of completeness; airplane manufacturers have done a great deal of testing, but without attempt at system and mainly to acquire data for immediate design needs, testing a particular type of plywood for use in a particular part of the airplane. The Forest Products Laboratory has probably done more work than any other organization, but even the work of the Forest Products Laboratory has merely scratched the surface of the subject.

Opportunity exists, therefore, for theoretical investigation; for the testing of plywood as a material in various combinations of veneer; and for the testing of plywood in the many curious combinations of stresses and many curious uses to which it has been subjected in the airplane.

The first, and perhaps the most important, theoretical investigation would be in constructing a logical basis for computing the strength of any panel, given the strength and elastic properties of its component materials.

The theory of stresses and strains of a nonisotropic or aeolotropic material is already sufficiently formidable. The texts in elasticity (Lamb excepted) are likely to write down the fundamental relationships in tensor or dyadic form, with a formidable array of symbols, and to say that no further consideration will be given to the theory of aeolotropic materials. It would be of interest to engineers if this theory and its connotations were brought in closer relationship to wood or plywood as they employ it. The use of two isotropic materials in combination introduces sufficiently difficult problems in structural analysis. The use of plywood superimposes on the theoretical difficulties of the aeolotropic materials the theoretical difficulties of two materials having dissimilar properties.

Whether or not it is possible to construct a rigidly accurate theory, it is difficult to say. At any rate, the theoretical work would take far too long. While, as stated previously, the classical theory should be placed before the engineer in more palatable form, the better approach is to pursue the pioneer methods of Basquin, Norris, and others and construct semitheoretical, semiempirical formulas, carefully checked by strength tests.

The strength data for wood itself, particularly in regard to shear, are quite meager. At least for the woods entering most frequently into airplane construction, we should like to know all available strength and elastic properties, along the grain, and perpendicular to the grain. (Incidentally, our information as regards dynamic effects, impact, fatigue could be very usefully extended. The two strongest arguments against the use of plywood in combat airplanes are that we do not know its dynamic and fatigue properties and fear the effect of extreme temperature variations.) However, the most complete information on the characteristics of the component veneers is of little service to the designer unless he can estimate the strength and elasticity properties of plywood. What, for example, is Poisson's ratio for a panel? What is the combined modulus of rigidity in varying directions? How can strength and elastic properties be estimated when various angular direction for

component veneers are employed? What are the properties of the panel when subjected to a combination of loads? The semi-empirical, semitheoretical methods must be extended and checked up by test to answer these questions; otherwise endless testing will never bring us to a firm knowledge.

A great deal of such work is being done by various manufacturers. It would be a splendid task for this committee to serve as a co-ordinating agency.

STRUCTURAL THEORY

After many years of confusion, the structural theory of metal-covered semimonocoque construction of wings and fuselage has now taken fairly definite shape. This theory is still partly empirical but it works and gives results which agree with tests. When plywood construction is adopted, we have to begin all over again, though there is the advantage that the structural analysis of the metal structure is there to serve as an analogy. A great many research problems immediately impose themselves, of which the following are typical examples:

(*a*) In thin metal skin, the use of stiffeners is general. By partly empirical, partly theoretical methods, it is possible to determine what width of sheet in compression is co-operating with the stiffener, and what is the strength of the combination. One of our first tasks is to obtain similar methods of computation for plywood skin acting jointly with wood stiffeners.

(*b*) One of the arguments in favor of plywood is its much greater local stiffness for a given weight as compared with steel or even aluminum. If this argument is really valid, then in plywood the stiffener should disappear and the construction should become purely shell or truly monocoque. Then we must learn to calculate the strength of a thin cylindrical shell under a combination of bending moment, shear, and torsion.

(*c*) For metal, granted that we know the strength of a reinforced flat plate in edge compression, we can estimate the additional strength due to curvature of the plate or skin. Similar knowledge must be obtained for plywood, probably by the testing of plywood cylinders in edge compression. We must at the same time ascertain how such additional strength, due to curvature, is related to the composition of the panel.

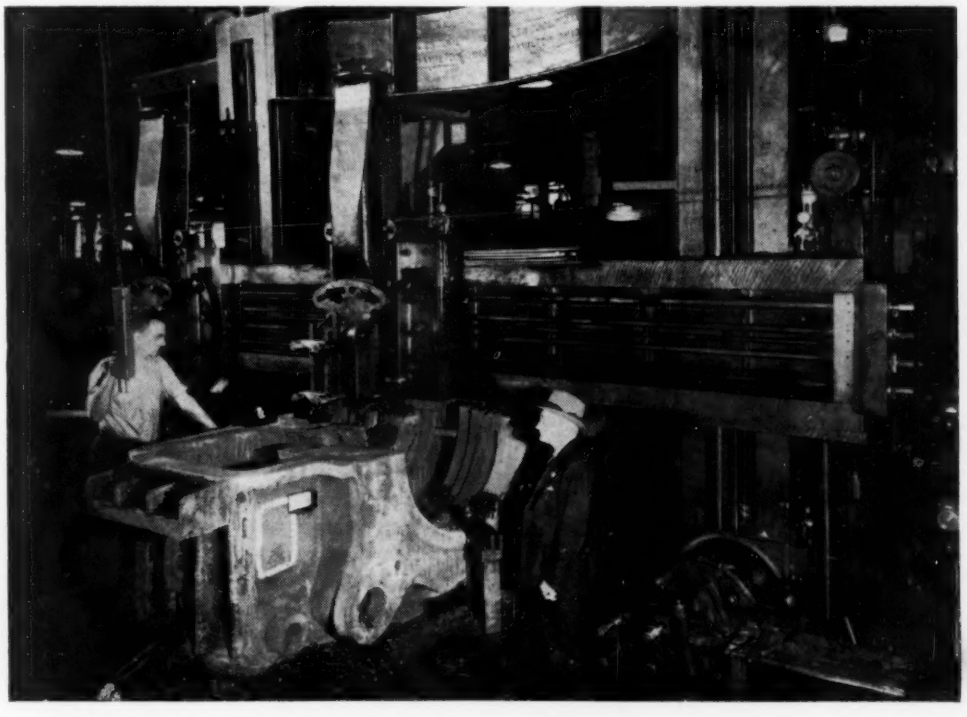
(*d*) When does the ordinary theory of bending cease to apply? What happens when there is stress concentration? Are our usual theories applicable in such cases? Besides theoretical work, there would seem to be room here for the use of strain gages, possibly embedded in the wood.

(*e*) We understand the buckling of a thin metal skin, whether it is in shear due to torsion, or in combined shear and compression, as on the upper surface of a wing. We even know under what torsional conditions the curved skin of the nose web will buckle or wrinkle. It is frequently said that, because of its greater thickness and local rigidity, plywood skin is not susceptible to buckling, and it is further said that it should never be allowed to buckle, even to the extent of the wrinkling which occurs in the tension-field beam. Both statements are incorrect. If a plywood structure is designed in refined fashion, buckling may become a very real problem, and if wrinkling (with subsequent disappearance of the wrinkles) occurs at very high load factors, then it will be admissible even in plywood construction. Hence both a theoretical and experimental approach to the buckling of plywood skin under various loading conditions is quite appropriate.

The foregoing constitute only a few of the structural questions which arise in the introduction of plywood. These and similar questions will not be solved by any one organization. The committee has a splendid task before it in co-ordinating the work of many design, construction, and laboratory organizations, each of whom may successfully tackle one small part of the common task, and by such co-ordination and by synthesis to build up a body of knowledge comparable to that already existing for the all-metal airplane.

BIBLIOGRAPHY

With the aid of several members of the committee, a large number of references have been collected which are in process of classified compilation. These references are to articles in trade journals, papers before technical societies, government reports, and the like. It has been suggested, however, that the bibliography would be quite incomplete without inclusion of at least the most important patents covering bag-molding and other plywood processes. Suggestions as to pertinent patents would be welcomed.



PRIDE OF THE COLUMBIAN EXPOSITION GOES FROM 4F TO 1A

(A 12-foot planer which was exhibited at the World's Columbian Exposition at Chicago in 1893 has been revitalized at one of General Electric's New England plants and is helping to turn out propulsion equipment for combat and cargo ships. The machine was rebuilt at a cost of $25,000 under the supervision of Tom Brown, one of the plant's veteran planning men, and it is equal in performance to a new one, which, if it could be bought today, would cost $125,000. Before Brown gave the machine its new lease on life, it was a tedious job to move the tool head or the cross bar. Now these and other similar operations are made easier and faster by electric push-button control. Mr. Brown has been with G. E. 23 years. He started as an apprentice and worked his way up to his present position of planning and time-study supervision.)

ELEVATOR WIRE-ROPE MAINTENANCE

Elevator Service Bulletin No. 1

AS WIRE rope must be replaced periodically, and as the material situation is such that considerable difficulty already exists in securing replacements, it was decided to make this the subject of the first of the series of service bulletins now being prepared by the Executive Committee for the American Standard Safety Code for Elevators to make available promptly information on the things that can be done to lengthen the safe life of wire rope. Other bulletins in this series will be:

No. 2 Elevator governors, safeties, and buffers.
No. 3 Hoistway doors and interlocks.
No. 4 Hoisting machines and brakes.

I INTRODUCTION

In June, 1941, the Sectional Committee for the American Standard Safety Code for Elevators, Dumbwaiters, and Escalators voted to discontinue work on the revision of that code for the duration. A short supplement containing a few necessary modifications and all interim interpretations was issued in lieu of a revision in April, 1942.

By the time the annual meeting of the Sectional Committee was held in June, 1942, it was evident that the acute shortage of repair and replacement parts would result in a marked decrease in elevator safety unless the utmost care was used in maintaining, as effectively as possible, such important items as cables, undercar safeties, and their associated mechanisms, interlocks, hoisting engines, etc. The sectional committee therefore suggested that the executive committee prepare a series of service bulletins covering such equipment.

As these bulletins are not intended for legal adoption or enforcement they have not been given the status of an American Standards Association project but have been prepared quite informally by the Executive Committee as its contribution toward elevator safety during the emergency.

It is the hope of the executive committee that these bulletins may be of real value to owners of elevators, and that they may, by calling attention to certain work that may be done and certain precautions that may be taken, be a means of maintaining the excellent safety record made by vertical transportation during the last two decades.

II FACTORS AFFECTING THE WEAR OF WIRE ROPE

1 Wire ropes by which elevators and their counterweights are suspended and those used to operate elevator safety devices are replaceable items that are almost unobtainable today, and the maximum possible life consistent with safety must be obtained from each set.

2 The service given by wire rope is generally measured in miles. Mileage, however, is not a safe criterion except for comparison between cars of approximately the same rise, duty, and number of landings. The number of round trips is a better measure. The service which may be obtained from a given set of ropes under a given duty cycle is made up of two different groups of factors:

A Those over which the owner has little or no control and which in total result in what we may call "normal wear." These factors include the relative hardness of rope and sheave; the ratio of sheave diameter to rope diameter; the shape of the groove, and the type of wrap (single or double), and similar items involved in the basic design of the elevator hoisting machine and the layout of the particular installation.

B Those factors (not necessarily arranged in order of importance) which may be reduced or eliminated by careful maintenance methods. Among these are:

a Lack of rope lubrication.
b Unequal or variable rope tensions.
c Misalignment of sheaves.
d Lack of maintenance of sheave grooving.
e Poor brake setting.
f Unduly high peaks of acceleration and retardation.
g Change in top and bottom hoistway clearances.

3 A wire rope is, in effect, a machine with a large number of parts working together in close proximity and moving relative to each other.

1 DISCUSSION OF FACTORS AFFECTING WEAR

(a) Need for Rope Lubrication.

4 Elevator ropes are made up of several strands laid about a center of hard fiber. The purpose of the core is twofold: First, to support the steel strands in their proper relative position, and, second, to act as a reservoir of lubrication. This fiber core is treated by the manufacturer with a lubricant which serves to lubricate the wires in the strand and to retard the absorption of moisture.

5 The lubrication supplied by the manufacturer will not last the full life of the rope, so the owner must relubricate the rope periodically if maximum service is to be secured. The frequency of lubrication will depend upon the amount of lubricant retained by the rope, the amount of use of the elevators, the factor of safety of the wire ropes, the temperature of the hoistway in which it is used, and other factors. Continuous lubrication may offer certain advantages over periodic lubrication. As a practical guide to the need for lubrication, a finger wiped in a sheave groove should show a faint smudge and have a slightly oily "feel." If this test leaves the finger dry and clean, lubrication is needed.

6 With a traction drive, the elevator is moved because of the adhesion or friction between the driving sheave and the ropes. With excessive application of lubricants, with lubricants having high viscosity, and particularly with lubricants containing solids, such as graphite, mica, asbestos, soapstone, or similar substances, the coefficient of friction between the rope and sheave may be so reduced that a dangerous slide may result. With traction elevators, the lubricants and the amount used should be limited to those supplied or approved by established elevator or rope manufacturers. After a rope has been

Prepared by the Executive Committee for the Safety Code for Elevators, Dumbwaiters, and Escalators of the American Standards Association.

relubricated a test should be made before the car is put in service. The empty car should be run in the up direction and stops made at various landings. Any noticeable slide of the ropes during acceleration or retardation is an indication that the lubrication is excessive.

7 If compounds containing graphite or similar solid lubricants have been used on the ropes of traction elevators to such an extent that slipping occurs, the ropes and sheaves should be scrubbed down with a stiff bristle brush saturated with kerosene or a nonflammable or high-flash-point solvent, wiping the rope and sheave with a clean dry rag.

8 Where drum machines are used and the hoisting ropes are fixed or anchored to and wind on the drum, heavier lubricants and those containing solids may be employed but not to the extent that such solids can build up in sheave and drum grooves.

9 Proper lubrication will prolong rope life by reducing the abrasive action of wire on wire or strand on strand. It will retard core deterioration, thus eliminating excessive distortion of the rope where it runs over sheaves or winds on drums. It will also retard corrosion of the rope by providing a moisture-repellent coating.

10 Before being relubricated, ropes should be thoroughly cleaned. Where continuous lubrication is provided the rope should be periodically dry-brushed to clear the crevices of accumulated grit.

(b) Rope Tensions.

11 Where an elevator is suspended by two or more ropes, the rope tensions should be as nearly uniform as possible and manual adjustment made when necessary.

12 The two principal causes for variation in the tensions between elevator ropes in a set are:

(1) Differences in length of the ropes.

(2) A differential action due to differences in sheave groove diameters and variations in cable diameter.

13 In a group of ropes cut from the same reel to the same length and carefully adjusted to the same tension, each rope will stretch a different amount and after a few weeks or months some of the ropes may be quite loose, whereas a few may be carrying an excessive load. It is necessary to equalize tensions if maximum rope life is to be obtained.

14 Most of this stretch takes place early in the life of ropes, and if the tensions are adjusted once or twice during this period of rapid and uneven stretch, the ropes will maintain their tensions fairly well for considerable periods during their remaining life.

15 The best place to test the tension is from a landing near the center of the hoistway, with the car at the bottom. When the ropes are pulled toward the landing, the greater the deflection for a given pull the less is the tension in the rope. A spring balance will enable the mechanic to exert the same pull on all ropes. The deflection may be measured with a rule.

16 The tensions should be equalized by turning the nuts on the shackle rods, then running the car up and down the hoistway to distribute the tensions on both sides of the drive sheave and retesting the tensions. This process should be repeated until the tensions in the ropes are substantially equal. Tension adjustments must not be made by twisting or untwisting the rope. After adjustment is completed, be sure that lock nuts are tight and cotter pins are inserted.

17 A more accurate method of equalization of tensions is to place the car at the bottom of the hoistway, deflecting each rope in turn not more than 1 per cent of its length, releasing it, and counting the vibrations for a fixed number of seconds, say, 10. This may be done from a landing near the center of the shaft. Where the ropes have been so adjusted that the number of vibrations are the same within the accuracy of an ordinary watch, the tensions are practically equal. For comparatively short ropes the vibration test should be made with the car empty to increase the time of each vibration, whereas for long ropes the car should be loaded, both to decrease the time of vibrations and to cut down secondary vibrations.

18 When used, rope equalizers must be lubricated frequently, examined, and adjusted to center the available travel, or they may present a hazard in themselves.

19 Ropes of a given nominal size vary in diameter[1] from rope to rope and there are small variations in diameter of a single length of rope. Further, there frequently are slight differences in the width and depth of sheave grooves so that ropes do not seat to exactly the same depth in the sheave giving unequal pitch diameters so that differential action is set up resulting in wear of the ropes. It is important to check the seating of ropes and, where the difference is considerable, the sheaves should be regrooved by competent mechanics.

(c) Alignment of Sheaves.

20 The alignment of all sheaves, the lubrication and condition of bearings should be checked periodically, as wear, settlement of building foundations, and similar causes may result in sufficient misalignment to affect rope life seriously.

(d) Lubrication of Sheave Bearings.

21 A traveling ("vibrating") sheave for a drum machine should slide as well as rotate on its shaft. Misalignment of sheaves, wear, or lack of lubrication may prevent proper lateral movement of the sheave as it rotates.

22 A rope used for long periods decreases materially in diameter. When ropes are to be replaced the condition of the grooves should be checked. This may be done by making a plaster-of-Paris or wax impression of the grooves. On this mold the width of the rope seat may be measured with calipers or a micrometer. If this is appreciably less than the diameter of the new rope, the sheave should be regrooved, otherwise the new ropes will not seat in the old grooves but ride on a pair of ridges in each groove, those ridges tending to cut into the new ropes. The diameter of the new rope should also be measured.[1] When it becomes necessary to regroove, it may be well to consult the company manufacturing the equipment, as most manufacturers have special tools for regrooving sheaves. For long rope life, be sure sheave grooves are of proper contour and width before reroping.

(e) Brake Action.

23 Harsh stops are detrimental to long rope life. Harsh brake action due to heavy spring pressure, brake-shoe wear, excessive dynamic braking, etc. tends to shorten rope life.

(f) Machine Acceleration.

24 An excessive acceleration shortens rope life. To get maximum service from wire ropes, keep the machine acceleration as low as practical. In many cases service will not be noticeably affected if the acceleration is reduced. Such adjustment should be made only by a competent elevator mechanic.

(g) Inching.

25 Rope life is affected by the number of starts and stops, and "inching" for a landing is frequently an aggravated start and stop. Poor operation will materially shorten rope life. It is important that operators be trained to handle the equipment properly.

[1] The diameter of a rope is the diameter of a circumscribing circle and is measured across an opposite pair of strands or, preferably, is the average of the readings over 3 or (in the case of 8-strand rope) 4 pairs of strands.

III INSTALLATION OF NEW ROPES

1 MAINTENANCE OF OVERHEAD AND PIT CLEARANCES

26 Allowance must be made in cutting the ropes to compensate for at least part of the anticipated stretch. The counterweight buffer must not bottom when the car is at the top landing, but a new rope must be long enough to provide the minimum top clearances required for car and counterweight. *See that counterweights do not compress their buffers if you want maximum rope life*, but for safety's sake do not install ropes that are too short.

27 When reroping is necessary, all ropes in a set on a traction machine and both ropes of the same pair on a drum machine should be replaced. The ropes in the set should all be of the same material, grade, construction, and diameter and preferably be cut from the same reel.

2 GOVERNOR ROPE REPLACEMENT

28 When replacing governor rope, if it is not possible to get a rope of the same material or construction, a full-load safety test (which is required by the American Standard Elevator Safety Code under these circumstances) should be made to see that the new rope will cause the safety device to function properly.

IV ROPE INSPECTION

1 ITEMS TO BE CONSIDERED

29 All ropes should be subject to competent periodic inspection. The factors that must be considered in judging a rope include surface wear, number of broken wires in a unit length (generally one rope lay—a full turn of the strand helix), distribution of broken wires among strands,[2] loss of rope lay, condition of the core, and corrosion or pitting. The proper evaluation of these items takes years of training: Good inspectors cannot be made overnight. If in doubt as to the remaining strength of a rope, the manufacturer might well be consulted.

2 FATIGUE FAILURE

30 Internal fatigue is difficult to detect and is consequently a greater hazard than surface wear. The surface of a rope may show little or no wear, but if the rope is bent over a short radius, the individual wires will snap, and in extreme cases a rope may be broken by hand. Such failures are more likely to occur in ropes of relatively low tensile strength, such as iron or the milder grades of steel, and are more frequent in governor or compensating rope usage, where ropes are lightly loaded. It is possible to locate such fatigue where there are actually broken wires by lifting, or attempting to lift, the individual wires. The breaks are generally under the strand or in the valley between strands. Ropes, particularly governor ropes, which have given abnormally long service, should be regarded with suspicion. If there are no or only a few broken wires, the rope should be bent to a short radius without kinking it; if fatigued, wires will part.

3 EXTENT OF WEAR AND ITS RELATION TO THE FACTOR OF SAFETY

31 In condemning worn wire ropes most inspectors do not differentiate between two sets of ropes which show equal wear, even though one set may be on a drum machine where the factor of safety of the suspension members is 6, although the other is on a traction machine, where the factor may be 12 or more, yet obviously this factor of safety should be taken into consideration. Ropes with low factors of safety should receive most careful and frequent inspection, particularly all ropes on drum machines.

V SPECIAL ROPE-MAINTENANCE ITEMS FOR DRUM MACHINES

1 RESOCKETING OF ROPES

32 The car and counterweight ends of ropes on drum machines are particularly subject to fatigue. This condition is more severe on overhead machines. The ropes on overhead drum machines should be resocketed every year, and on basement machines every two years. All socketing, whether on new rope or old, should be carefully inspected before the elevator is returned to service.

2 JUMPING OF ROPES

33 The most common cause of rapid deterioration of wire rope on drum machines probably is jumping the grooves with consequent overwinding. This may be due to a brake action which is too harsh, high retardation, or poor equalization, but probably will be found to be due, in part at least, to an excessively heavy car counterweight. In such cases a competent elevator company (preferably the company making the original installation) should be consulted as to the proper procedure.

VI SAVING ROPE BY REDUCTION OF SERVICE

34 Marked savings in wire rope may be effected by reducing the speed or by shutting down some of the elevators. Either of these steps will reduce the total number of miles run during any one day. A careful study of elevator traffic in a given building may result in revised schedules with fewer cars operating in "off peak" hours but with no serious curtailment of service. Skip stops or the elimination of down stops at second and third floors will give fewer stops and longer rope life. When curtailing service, care should be taken to avoid overloading the cars which are in operation, as excessive stresses will shorten the life of wire rope. In any event, the possibilities of saving wire rope offered by these methods are great and should be investigated most carefully.

A MAJOR SUBASSEMBLY
(Important power section being assembled in Buick production of military aircraft engines.)

[2] Some of these items were covered in a method which appeared in *Wire Rope Engineering* for July, 1932. The results of analysis of approximately 100 ropes by this method are reported in National Bureau of Standards, *Journal of Research*, Research Paper RP920, vol. 17 (September, 1938), which may be consulted in many reference libraries.

RUBBER REPLACEMENTS

By E. G. KIMMICH

GOODYEAR TIRE AND RUBBER COMPANY, AKRON, OHIO

THE eventual wartime replacement of natural rubber by the so-called synthetic rubbers is anticipated by the current government program, but the best estimates show a serious gap between requirements and the available supplies for the year 1943. The present situation is a race between the diminishing stock pile of natural rubber and the building up of our synthetic production. The Baruch Report shows that only with the strictest conservation and the utmost effort on synthetics can the gap be closed. Careful and restricted use of rubber will help reduce the gap, but to a large extent replacement of crude rubber by other materials is required.

RECLAIMED RUBBER—RUBBER EXTENDERS

Perhaps the most obvious replacement is reclaimed rubber, prepared from scrap. Reclaimed, or regenerated, rubber has been depended upon for many years as a source of material for the rubber industry, but to the extent that its production can be increased and its use confined to essential products, it becomes an important and effective, though not alone adequate, means of conserving our crude supply.

Reclaim is regarded as a material distinct from crude rubber as it does not possess all the properties of crude. Because the quality is not equal to the original rubber in all respects, there has been a feeling by some in the past that its use was an unwarranted cheapening of the product. However, economic conditions and the desirable properties of reclaim caused a large market to be established for this material, and it persisted through the period when crude rubber was selling at its lowest price levels, and reclaim was selling at levels actually above natural rubber.

Government specifications in the past have ruled out reclaim in many instances and have demanded a very high percentage of crude. This reflected the desire to buy, with public funds, the very best qualities available. War conditions have completely reversed this situation so that at present there are limitations in the other direction, maximum percentages of rubber either crude or reclaimed with emphasis on replacing crude wherever possible. It is to the credit of government agencies and the rubber industry that large savings of crude rubber have been made without dangerous reductions of service qualities.

It is difficult to process all-reclaim compounds without recourse to a small percentage of crude either as a cement or in the batch, to hold the component parts together until the article reaches the vulcanizing process. So long as production is confined to articles for essential uses, these very small additions of crude are readily justified.

Whereas the re-use of rubber by whatever process met resistance in some quarters in the past, it is now widely recognized as a useful replacement of crude natural rubber. The present favorable situation with regard to the supply of scrap rubber does not assure us of a continued adequate supply of reclaim so that replacement of reclaim in turn may become necessary depending upon the length of the war.

Rubber replacements within the compounds extend the amount of material that can be made with an available supply. Replacement by various compounding ingredients including sulphurized oils and other hydrocarbons, which in themselves have some rubber-like properties, saves much rubber for other critical uses. When these lower rubber percentages result in lessened quality the manufacturer indicates in some way that the article is of "war" or "duration" grade. Reduced quality is a small sacrifice in comparison with the savings of rubber, and in many cases, the quality exceeds expectations. In any event it would be unwise to build more quality into the product than is necessary to span the present critical period.

SYNTHETIC RUBBER

Of maximum importance is the replacement of crude and, possibly, the later replacement of reclaim by the remarkable synthetics now in production in rapidly increasing quantities known under the general classification of "synthetic rubber."

What the author believes to be the most concise and understandable description of the various synthetic rubbers is published as an appendix to the Baruch Report. That document should be read in its entirety by anyone desiring a thoroughly reliable digest of the current rubber situation. But, for the purpose of this paper, the author would point out particularly the statements appearing in the appendix on synthetics.

Buna S (a copolymer of butadiene and styrene) has by far the largest part in the national program—over 70 per cent. Its properties more nearly duplicate those of natural rubber than any other. It is not particularly oil-resisting but it has the other qualities necessary for the successful replacement of all the rubber in many products and most of the crude in others.

Buna N types (copolymers of butadiene and acrilonitrile) were developed in this country before the war. Chemigum, Hycar O.R., and Perbunan are names given to rubbers of this group, although by no means identical in their manufacture or in their final properties. These rubbers had made places for themselves prior to the cutting off of our imports, due to their unusual oil- and solvent-resisting characteristics. Buna N rubbers are most successful for bullet-sealing fuel and oil tanks for airplanes and for the bullet-sealing hose to connect these containers with the engines.

Neoprene, Thiokol, and Butyl each has an important assignment in the rubber program due to its individually advantageous properties. The first two were in substantial commercial production prior to the war, the third is more recent but was developed independently of the war. The expansion of the production of these materials was given an early approval.

Flexon and Norepol are potential replacers of rubber, but not yet in large production. Flexon is similar to Butyl rubber but producible with lesser amounts of critical materials for equipment. However, it requires dry ice in its process and this is thought to be the limiting factor in its manufacture.

Norepol is a relatively new polymer prepared from soybean oil and ethylene glycol. Low tensile and elongation limit its use at present to places where these properties are adequate for the service, but Norepol is also of potential value as an extender.

FLEXIBLE PLASTICS—NONRUBBER-LIKE REPLACEMENTS

The replacement of rubber of all forms by nonrubber and noncritical plastics is a matter of great activity at this time. Clear distinctions and classifications of the various materials

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have been very difficult. It appears useful, however, to include in one group those plastics which are inherently very rigid and which by additions of substantial quantities of plasticizers can be made flexible and to a considerable extent rubber-like.

Polyvinyls (possibly the chief of this group) are not originally rubber-like but can be made so to a large degree by mixtures with proper plasticizing and softening ingredients. Tubing, molded articles, impregnated and coated fabrics, are being made and successfully used. These are characterized by almost complete inertness to oils and chemicals and can be made very flexible. Thermoplastic properties limit their usefulness to places where extremes of temperature can be avoided.

One form of the polyvinyls based on polyvinyl alcohol is not altogether resistant to water even at room temperatures, but fortunately this condition is minimized by additions of certain materials. The polyvinyl group includes polyvinyl acetate, polyvinyl chloride, copolymers of the two with additional types being discovered from time to time.

Certain polyvinyl tank linings will handle any of the acids and alkalies for which rubber linings have been used and, in addition, can satisfactorily resist the action of nitric and chromic acids which are destructive to natural rubber. These synthetic linings are resistant to swell and deterioration by oil, gasoline, and aromatic fuels. "Ethyl rubber," prepared by plasticizing ethyl cellulose, can be used for many purposes formerly fulfilled by natural rubber, particularly where high resilience and heat resistance of vulcanized rubber are not required.

Rubber is also being replaced by many substitutes of non-rubber material having very little of the rubber-like properties with attendant sacrifices of desirable characteristics. In many cases wood bumpers can serve. Felt is used instead of foamed latex rubber in protective cushioning devices for military vehicles. For some purposes steel is used as the less critical of two materials.

An interesting example of rubber replacement has been worked out for small industrial-truck tires where rubber of all sorts was early prohibited. Resilient wheels are often necessary for industrial haulage within factories. The material used is known as "corolite" consisting largely of sisal or other cordage fibers impregnated with phenol compounds. Of course, this material is very hard and some of the cushioning formerly used has had to be sacrificed but the wheels are comparable to hard-rubber types and are much better than all metal in their effect on floors and loads and at the same time save considerable metal. The material, corolite, is adaptable to many uses where a fairly rigid substance of great toughness and oil and solvent resistance is needed. The material is thermosetting and thus useful over a wide range of temperatures.

COMPARISONS WITH NATURAL RUBBER

One permissible generalization is that no synthetic yet produced has all the properties of natural rubber. For this reason the replacement of the natural material can be accomplished only with knowledge of and proper selection of the synthetic best fitted for the particular use. While some of the comparisions are unfavorable to the synthetics, it is altogether fortunate that there are some important items on the asset side of the ledger for these man-made materials. By proper selection and compounding, synthetics having more oil resistance, more chemical resistance, and more heat resistance than natural rubber can be obtained. In the matter of cold resistance, natural rubber is generally better but there are a few very fortunate exceptions. The synthetic substances depend upon such plasticizers as do not stiffen appreciably at low temperatures, and some of the best ones for low temperatures are not suitable at high temperatures.

A deficiency common to all regenerated rubber, synthetic rubber, and flexible plastics is their relatively lower resilience. The failure to release all the stored energy immediately upon release of the load results in a rise of temperature which can, in some instances, become serious. This requires a change of design, or a reduction of the severity of flexing or earlier failure will be the result. This is the main reason why large-cross-section tires require considerable admixtures of crude. The thicker the cross section, the more pronounced is the amount of heat generated and the greater the difficulty of dissipating the heat. All of the easily flexed materials are relatively good insulators of heat.

A fairly reliable check on this property of resilience and heat build-up during flexing is the pendulum-rebound test where resilience as high as 90 per cent can be obtained with natural rubber compounded for maximum results in this property. Other natural-rubber compounds will show results in the range of 60 to 90 per cent. On the other hand, pendulum-rebound tests above 70 per cent are seldom obtained with any of the rubber replacements and the values range all the way down to 30 per cent.

The replacement materials generally are deficient in the property called "tack," a peculiar adhesiveness of unvulcanized crude rubber which facilitates the assembly of the component parts in the preparation of the uncured products. This quality of crude is utilized to great advantage in rubber cements. Intensive research has brought to light proper softening agents and procedures so that the manufacture of synthetic articles has been put on a practical basis, although rather generally it is true that the productivity of the manufacturing equipment is considerably reduced.

It is seldom found that a specific property is possessed in high degree in one of the materials and absent in others. Rather, it is a matter of degree resulting in much overlapping. This is often a fortunate circumstance permitting choice of materials on the basis of availability. In the allocation of various types of rubber, the industry has been assisting the War Production Board in finding the products where each one can be used to the best advantage and replace the largest amounts of crude rubber.

REPLACEMENTS IN PEACETIME

Questions regarding the permanency of the rubber replacements during peacetime are often asked. Of course, predictions at this time can be based only on individual opinion. The relative prices prevailing after the war will have a large bearing on the subject. But to those of us who have worked with the synthetics and to many who have used them, it seems certain that for many uses natural rubber can never regain its former position. This applies particularly to the oil-resisting synthetics, some of which warrant the designation as "oilproof" materials. Formerly where a flexible oilproof hose or molded item was needed our only recourse was to compound natural rubber so as to increase slightly its naturally very low oil resistance. Then by carefully working out designs which protect the rubber as much as possible from exposure to the oil, satisfactory constructions were worked out. Before the war, and certainly this will continue after the war, synthetic suction and discharge hose for loading and unloading oil tankers had practically displaced rubber hose. Gasoline-service-station hose with synthetic lining and cover has very nearly replaced the older types. These are but two of the many instances where synthetics have already demonstrated their worth as compared with products of natural rubber.

The discovery and development of the many types of synthetic materials may well indicate the possibility of further improvement and that materials and processes will be discovered which will eliminate the present deficiencies. If such be the case, natural rubber with all its remarkable characteristics will be forced into secondary position even if its former low prices again obtain.

Evaporative-Cooling PRIMER *for* TEXTILE MANAGEMENT

By M. H. IRONS

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MAINTENANCE of adequate relative-humidity standards for protecting textile fibers from the terrific punishment given them in all the departments from the pickers through the spinning and weaving departments has long been commonplace.

Along with the protective function of humidity came a reduction in operating-room temperature which, though very vivid when the humidifying system was first installed, tends to be forgotten until a breakdown of a long-installed system occurs on a hot summer day and inside temperatures go sky-high.

Demands for high production have resulted in higher machinery speeds with consequently greater installed horsepower and generated internal frictional heat. The resulting unbearable room temperatures have brought textile management to place more stress on the aforementioned evaporative-cooling effect of humidifying systems.

Management's problems in the selection of evaporative-cooling systems are:

1 What is it all about?
2 How much should I buy?
3 Can I use present equipment?

WHAT IS IT ALL ABOUT?

A spinning room may be likened to a big box and the windows to holes in the box.

If heating coils, a motor, or the frictional heat of operating machinery, lights, etc., come into play within the box, the interior temperature will surely rise in proportion to the concentration of this heat generation within.

If the room is airtight the temperature will rise to a point where heat input equals heat transfer through the walls, floor, and ceiling, causing temperatures which in some textile processes might go as high as 150 F.

If, instead, the open holes are exposed to wind, or if the air is introduced by fans or other means, the air flow through the box will produce a slight lowering of room temperature which is reflected in the rise in temperature of the air going through the box as it is exhausted. The greater the air flow, the lower the interior temperature.

Spray water "directly" into that air and we have another means of reducing air temperature. The evaporated water or water vapor disappears as a fluid and reappears as "humidity" in the room air, readily measurable by humidity indicators. The change of state from fluid to vapor has absorbed heat just as surely as evaporating water in a steam boiler absorbs heat from the burning fuel.

Fortunately the cooling effect of evaporating water into air is considerable as is shown by the following comparison: One pound of evaporating water will offset the heat produced by a 300-watt light per hour; three pounds of evaporating water will offset the heat produced by a 1-hp motor per hour; and one pound of evaporating water will remove approximately as much heat as will seven pounds of melting ice.

The amount of cooling by evaporation is determined by the amount of water which can be evaporated. The amount of water which can be evaporated is limited by the amount of moisture which the air can absorb. The fresh air obviously can "pick up" the difference between outside-air moisture content and the specific desired moisture content within the room (obviously a weave room at 85 to 90 per cent has a high "top ceiling" for moisture pickup and hot dry climates would have a low floor for moisture pickup).

Taken in steps we have effected a slight lowering of temperature by ventilation alone and a further reduction by ventilation plus evaporation.

The third step to produce further cooling has to do with the amount of evaporation that can be performed. Obviously two cubic feet of air can absorb twice the water vapor that can be absorbed by one cubic foot, and in a "direct" system the greater the air flow (plus the water to go with it) the greater the reduction. Infinite air flow would cause an inside wet-bulb temperature approaching as a limit the outside wet-bulb temperature. Indirect systems will have a room dew-point emperature approximating the outside wet-bulb temperature.

TYPES OF SYSTEMS

Direct Systems. A direct evaporative-cooling system is any system which evaporates moisture directly within an enclosure which is not airtight. Under this heading should be placed all so-called "humidifying" systems which utilize the following:

1 High-duty humidifiers consisting of a pressure-type water spray within a suspended cylinder through which passes a forced air flow or an induced air flow.

2 Atomizers which by means of a compressed-air nozzle induce a water flow into an air jet where it is broken up into a fine mist and distributed in the room.

3 Centrifugal humidifiers, incorporating a high-speed disk to which water is fed, delivering a fine sheet of water to peripherally located teeth, by means of which the water is broken up into a fine mist by centrifugal force. The air delivery from a propeller-type fan receives this mist and distributes it in the room proper.

4 Systems using short ducts with many outlets delivering a fine mist or fog. The means for producing this fog within the duct are variations of (1) or (3), and the air flow is usually recirculation of room air under forced circulation.

5 Open pans, air blown over wetted wicking, direct introduction of steam, etc.

These systems are not graced by the term "evaporative-cooling system," where there is no controlled fresh-air flow, although wherever a humidifying system is operating, there is an air change if it is only a natural air change (windows, build-

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ing leakage, etc.) and, consequently, evaporative cooling is taking place.

To make these systems evaporative-cooling systems in the full sense of the word it becomes but necessary to introduce fresh air by means of an air-handling system, such as a duct distributing system or unit ventilators positioned at the windows, and then to incorporate control of that air-handling system. In the case of (4) suitable fresh-air and recirculation dampers under control need only to be installed.

Control. There are two types of control to be applied to the air-handling system (humidity control of the existing humidification system being assumed):

1 Temperature. The function of temperature control is more in the nature of a low-limit operation to prevent the temperature during the fall, winter, and spring from going below a fixed selected minimum at which point it can be held. During summer months room temperatures are at the mercy of the outside wet-bulb temperature with full fresh-air capacity being used most of the time and no fixed temperature being maintained constantly.

The thermostat, which may be pneumatic or electric, gradual or positive acting, functions to position the fresh-air and recirculating dampers in the proper ratio to maintain its setting.

2 Humidity. Supplementary humidity control may be considered under two headings:

(*a*) "Underhumidity." The existing humidification system may be adequate for the fresh-air capacity to be installed, in which case temperature control only will suffice. In any event, if the capacity of the humidification system is not adequate to maintain desired inside relative humidity under extremes, a supervisory humidity control can be installed to close off the fresh-air dampers when the evaporation capacity is overtaxed by an extremely hot dry day which exceeds design specifications.

(*b*) "Overhumidity." In light-heat-load low-humidity (50 to 55 per cent) rooms during high-humidity "dog days," periods of overhumidification may result from bringing in full outside air. A second type of "supervisory" humidity control acts, when normal conditions have been exceeded, to reduce the quantity of outside air, allowing the room temperature to rise until this condition corrects itself by restoring the desired lowered relative humidity.

Indirect Systems. This is the familiar air washer or central system in which fresh air, room air, or a mixture is passed through a series of sprays. The air emerges from the last spray saturated and at approximately the wet-bulb temperature of the entering air when the spray water is recirculated and unheated or cooled. This 100 per cent relative humidity air is then distributed to the room through a system of distributing ducts and outlets. No visible moisture is delivered from these outlets, humidification being performed "indirectly" at the washer.

Heat pickup in the room, or reheating, or both, reduces this humidity to the required maintained standard.

All air will be saturated regardless of how low the outside relative humidity goes, the exit air having a moisture content or "dew point" within one degree of the outside wet-bulb temperature. Control is generally by the dew-point method, whereby a fixed temperature differential between this "dew-point temperature" and the room temperature results in a constant relative humidity maintained thermostatically.

In the summer the room temperature fluctuates with the outside wet-bulb temperature. In the winter, a constant temperature can be maintained by one or all of (*a*) preheating, or (*b*) mixing the entering air, or (*c*) heating the water sprays.

Combination Systems. Duct distributing systems, combining washing or "indirect" evaporation as well as "direct" evaporation within the room, make up a third category of systems.

The direct evaporation may be produced by atomizers, high-duty humidifiers, centrifugal humidifiers in the room proper, or in the form of supersaturation carried along in the air stream through the outlets into the conditioned area.

Reductions in total air handled can be effected with "direct systems" or combination systems over "indirect systems," which may be quite a factor in these days of wakened interest to the profits from air cleaning.

Unit Systems. Units automatically supplying fresh or recirculated air or a mixture, as well as humidifying, heating, or filtering, may combine one or all of these functions under control.

Whereas central systems are tailored to the job, unit systems will always have the appeal of flexibility where a fast-changing industry may put a spinning room where a weave room was last year, or higher speeds increase the heat generated. Unit systems may be moved and re-used or their number increased on the spot with equal facility.

HOW MUCH SHOULD I BUY?

Design. The outside wet-bulb temperature is a measure of the total heat content of air and is the theoretical minimum temperature that can be reached by evaporative cooling.

Let us consider a mill in Georgia, for example, assuming a room with no internal heat, to be cooled "directly" by evaporation within the room and fresh air passing through it. The outside-air conditions are 91 deg dry-bulb temperature; 78.5 deg wet-bulb temperature; 74 deg dew-point temperature; 126 grains of moisture per lb; 58 per cent relative humidity.

If we saturate the air to the following relative humidities, the room conditions will be:

Relative humidity, per cent	Dry-bulb temperature, deg	Wet-bulb temperature, deg	Dew-point temperature, deg
100	78.5	78.5	78.5
90	81	78.5	77.6
80	83.7	78.5	76.7
70	87	78.5	75.7
60	90.2	78.5	74.2

Obviously to get below 58.5 per cent would require dehumidification and not evaporative cooling. Of pointed interest here is the fact that higher relative humidities allow lower room temperatures to be maintained.

If this were an actual weave room at, say, 80 per cent relative humidity, there would be internal heat to be picked up by the "air change" so that the inside wet-bulb temperature would be elevated above that of the fresh air. A reasonably designed system might then be able to produce actually an 87-deg dry-bulb temperature, rather than the theoretical 83.8-deg given. If this were a spinning room with high heat pickup, maintained at 60 per cent relative humidity, the inside temperature for a reasonable air change then might be 95.5 deg, rather than the theoretical 90.2 deg.

The foregoing outside wet-bulb temperature is an extreme for central Georgia, probably not exceeded during more than 5 per cent of the summer cooling time. More favorable wet-bulb temperature would give lower produced inside temperature. For example, a 72-deg outside wet-bulb temperature could result in all of the inside conditions cited, being reduced 6.5 deg approximately.

Fig. 1 shows two temperature records from two identical rooms in a northern mill, one cooled and one uncooled. The outside conditions were 90 deg dry-bulb, 68.5 deg wet-bulb

temperature, and the produced inside temperatures were, respectively, 90 to 100 deg in one case, and 80 deg maintained in the other case, showing in a striking way the benefits possible from evaporative cooling. Needless to say the 90 to 100-deg room is now also equipped with evaporative cooling. The rooms were both rayon weave rooms of the same loom layout and size with 65 per cent relative humidity maintained.

Cooling in this case is "direct" by means of atomizers in the room proper, coupled with an inlet-air-handling system, consisting of automatically controlled ventilating units without ducts and positioned at the windows. At the opposite side of the room are controlled exhaust louvers for air egress.

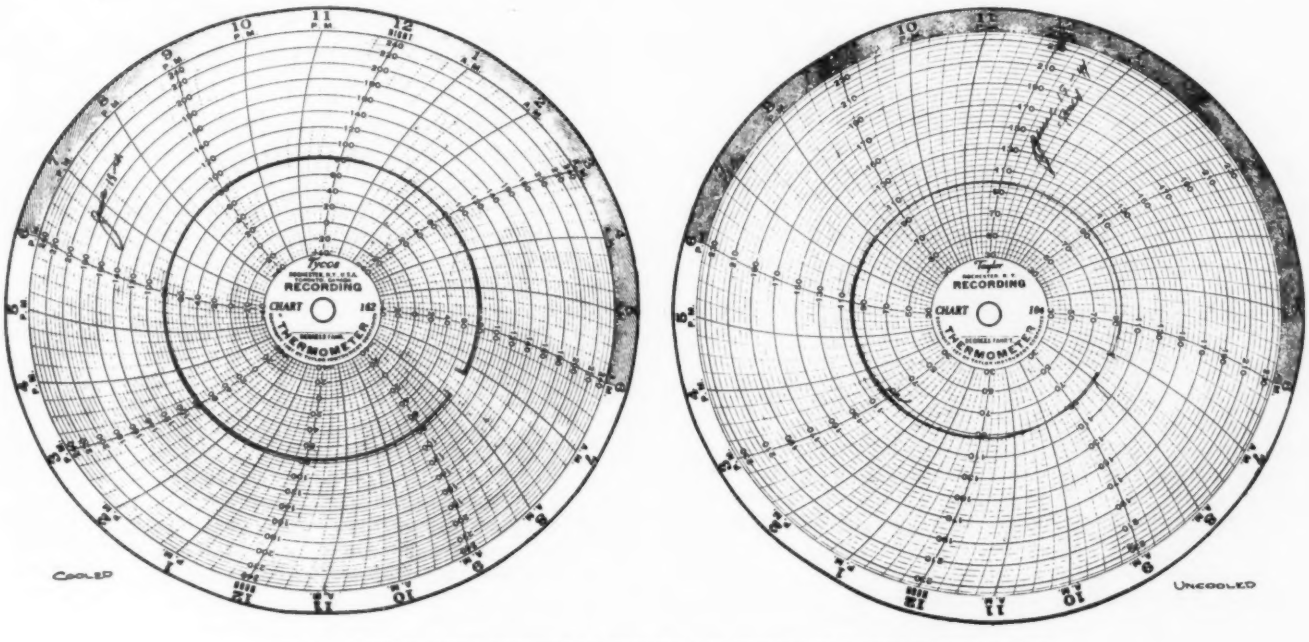

FIG. 1 TEMPERATURE RECORDS OF COOLED AND UNCOOLED RAYON WEAVE ROOMS

Under the limitations of evaporative cooling it would be well to point out here a common misconception that no evaporation or cooling can take place when the outside relative humidity is as high as the relative humidity desired inside.

Assume outside conditions 88 deg dry-bulb temperature; 76.5 deg wet-bulb temperature; 60 per cent relative humidity; 118 grains of moisture per lb of air. The room to be cooled is a high-heat-load spinning room held at 60 per cent relative humidity and equipped with an evaporative-cooling system. A reasonably designed system might produce a 94.5 deg dry-bulb temperature and 60 per cent relative humidity against such an outside condition. Air at 94.5 deg and 60 per cent contains approximately 24 per cent more moisture than air at 88 deg and 60 per cent, and this 24 per cent represents the amount of water which can be evaporated without changing the relative humidity even 1 per cent.

All of the preceding applies only to "direct" systems. Indirect systems will have the same room dew-point temperature as the outside wet-bulb temperature for all humidities, and although the minimum possible temperatures are not quite as low as can be produced by the "direct" system the same rules apply, namely, the higher the inside relative humidity is carried, the lower the room temperature can be maintained.

FIGURING AN ACTUAL JOB

The cost of a job depends upon the size of the equipment, and the prime factor, determining the amount of air to be handled, water to be evaporated, etc., is the total internal heat load.

A data sheet, for evaluating all the elements going to make up this total, is given herewith.

It will be noted that there are three types of heat gains given in the data sheet:

1 Generated: Motors (this includes frictional heat given off by the driven frames, looms, etc.); lights; people.

2 Heat gain by conduction through walls, floors, ceilings, glass, etc.

3 Solar-heat gains such as direct sun on roof, walls, or glass.

If the management can reduce any of these factors, the size of equipment and the price of the job are automatically lowered.

Assuming all the elements of the first type, motors, lights, people, etc., are at their highest efficiency, no reduction can be looked for here.

The second type, "conduction," generally plays a small part in the total so a cautious eye should be given to money spent here for insulation, etc., lest we be guilty of "spending a dollar to save a cent."

Solar-heat gains very often play a major part, percentage-wise, in the total heat load, and careful attention should be given to reducing solar-heat gains by such means as spraying roofs, insulating roofs, painting windows, solar-refracting glazing, outside shading of windows by awnings, etc.

After the foregoing heat gains have been totaled, we are ready to design a system to cool them.

Direct Systems. The particular locality involved may call for designing against an outside condition of 96 deg dry-bulb temperature; 75 deg wet-bulb temperature; 38 per cent relative humidity; 66 deg dew-point temperature; 37.81 Btu per lb of air total heat; 96 grains of moisture per lb of air.

It is decided under these conditions to maintain within the room 83 deg dry-bulb temperature; 77.9 deg wet-bulb temperature; 80 per cent relative humidity; 76 deg dew-point temperature; 40.54 Btu total heat; 136 grains of moisture per lb of air.

Obviously fresh air introduced will pick up 2.73 Btu per lb

and dividing this into the total heat load will give the pounds of air per hour to be required.

In like manner, 40 grains of moisture will be picked up per pound of air, and the total evaporation in pounds per hour is equal to pounds of air per hour multiplied by 40 and divided by 7000.

Instead of giving the inside and outside design conditions

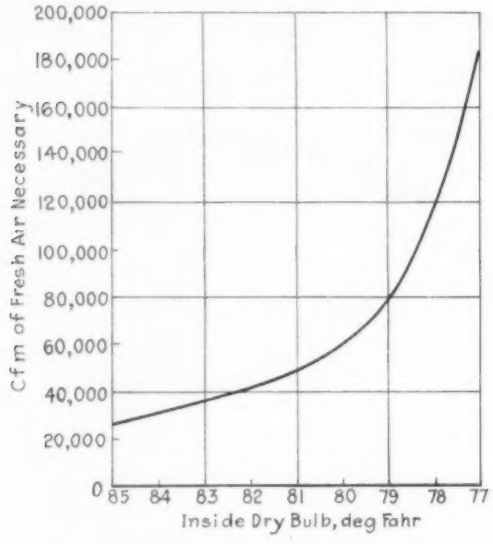

FIG. 2 DIRECT EVAPORATIVE-COOLING SYSTEM

(Curve showing fresh air necessary to maintain 85 per cent relative humidity with various inside dry-bulb temperatures. Outside conditions: 96 deg dry bulb; 72 deg wet bulb; 30 per cent relative humidity; heat load 1,000,000 Btu per hr.)

mentioned the specifications might read "system to maintain 8 deg above outside wet-bulb temperature." Although this "8 deg above" designation does not hold exactly for all conditions, it is reasonably accurate for approximating performance at all outside wet-bulb conditions.

It is obvious also that it costs more to cool to 5 deg above the outside wet-bulb temperature than it does if one is satisfied to cool to 8 deg above the outside temperature. Diminishing returns set in to affect this decision and careful consideration should be given to this matter before demanding an extra 3 deg of cooling which requires double the outlay for equipment.

Fig. 2 shows the fresh-air requirements in a room using a direct system of evaporative cooling.

A design of 10 deg above the outside wet-bulb temperature (82 deg) would require 42,000 cfm of fresh air.

To improve the cooling 2 deg (80 deg room temperature) an additional 20,000 cfm of fresh-air capacity would have to be installed with a cost commensurate with the larger equipment needed.

To improve the cooling an additional 2 deg (78 deg room temperature) a second addition of 57,000 cfm would be needed. It is apparent that management demands for cooling should be governed by the economical point for degrees cooled per dollar expended.

Although not shown, the evaporation requirements increase in approximately the same proportion as the air requirements, and Fig. 2 assumes that equivalent evaporation is provided.

Indirect System. In the indirect system the cooling effect is fixed by the difference between the dew-point temperature and the dry-bulb temperature at the established room relative humidity. Therefore, the same latitude in selection of size of system or degrees of cooling is not permissible.

In conclusion, the point can be stressed that many now operating "direct" humidifying systems can be more fully utilized for evaporative cooling and lower temperatures by:

1 Installing controlled fresh-air supply by means of unit ventilators or duct systems, which may or may not involve increasing evaporative capacity of the humidifying system now installed.

2 Increasing present evaporative capacity to allow full use of "natural ventilation" in such buildings as monitor types, etc., where ventilation is normally of a high order.

3 Check present humidity controls to see that the proper relative humidity is being maintained.

Spray-producing equipment should be regularly cleaned in both types of systems in order to maintain maximum capacity. If heat loads have been increased in a long-installed indirect system resulting in low relative humidities, correction may be effected by adding direct evaporative capacity within the room.

DATA SHEET FOR ESTIMATING EVAPORATIVE-COOLING SYSTEM

No.	Item					Btu per hr
1	Motors: Under 2 hp: Total hp ×					
	Over 2 hp: Total hp ×					
	or actual kw input × 3416					
2	People: Number × 700					
3	Lights: Total watts × 3.416					
4	Miscellaneous					
5	Total generated heat gains					
No.	**Item**	**Dimensions**	***A***	***U***	$T_o - T_i$	**Btu per hr**
6	Outside wall					
7	Outside glass					
8	Inside wall					
9	Inside glass					
10	Floor					
11	Ceiling					
12	Total conducted heat gains					
No.	**Item**	**Dimensions**	***A***	***FaI***		**Btu per hr**
13	Wall					
14	Wall					
15	Glass					
16	Glass					
17	Monitor glass					
18	Roof					
19	Total solar heat gains					
20	Total all heat gains—items 5 + 12 + 19					

Avoiding High STOKER MAINTENANCE— *Retaining* GOOD COMBUSTION

By A. R. MUMFORD

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AT the Fifth Annual Fuels Conference held at Easton, Pa., in 1942, the Coal Testing Code Committee sponsored a symposium on stokers. The purpose of that symposium was to place in the record any material that could be collected from the files of the manufacturers and the unreported experience of the manufacturers' service engineers. With the furtherance of this objective in mind the writer has examined many files and other sources of information in an attempt to segregate those items of interest to fuel engineers. The causes of trouble are so elementary that they will surprise many. However, the repeated recurrence of simple causes of high maintenance is a definite indication that the user of stoker equipment must be made aware of these causes if he is to avoid high maintenance.

GENERAL

High stoker maintenance is comparative, and the normal to which comparison is made exists in the mind of each operator based on his experience. Maintenance above normal is high.

Probably the greatest single item associated with high maintenance is the burning of stoker metal. Other items of maintenance appear from time to time, such as wear, but this is not usually abnormal in the well-designed stoker. The burning or overheating of stoker metal continues until the specific cause or causes have been found and eliminated. During this emergency, the difficulty of securing replacement parts is sufficient incentive to operators to eliminate all causes which have been shown to contribute to stoker-metal burning and this paper points out several which have been found on different types of stokers.

Stoker metal burns because it gets too hot and for no more complicated reason. To protect stoker parts from burning, the designers incorporate sufficient air-cooled surface in the design of the part so that the air supplied for combustion takes up heat from the part and keeps its temperature below the damage point. This is not, generally, sufficient protection for all parts of the stoker, and it is customary to depend upon an insulating layer of ash or fuel to reduce the amount of heat reaching the metal.

For the purposes of this paper, only two problems associated with the burning of stoker metal will be considered, the maintenance of an adequate flow of air to remove the heat from the part as fast as it is delivered, and the maintenance of a porous insulating layer on the fire side to keep the flow of heat to the stoker parts down to a value which can be picked up by the combustion air. It is immediately apparent that the insulating layer must be porous so that it does not retard the flow of cooling air sufficiently to permit the temperature of the stoker parts to rise to the burning point.

Mechanical stoking was developed to supersede the labor of hand stoking and to make the combustion conditions more uniform than those associated with the intermittent firing of fuel by hand. Most stokers move the fuel progressively from the point at which it enters the furnace as green fuel to the point at which the residue is discharged. In chain-grate or traveling-grate stokers, the progressive motion of the fuel is essentially in one plane without vertical agitation. In underfeed stokers both single- and multiple-retort, the progressive motion is complicated by upward and sidewise motions necessarily superimposed on the principal longitudinal motion. Because these motions serve to move the fuel, with its noncombustible residue, through areas or zones in which the temperature differs because of combustion conditions, it is advisable to understand the progress of the fuel clearly.

The author finds no clearer description of the progress of fuel in a multiple-retort stoker than the following, given by A. S. Griswold and H. E. Macomber:[1]

> The principle of operation of the underfeed stoker, handling bituminous coals of the coking type, depends upon a rather definite physical movement and progress of the fuel on the stoker corresponding to the physical changes which take place during the combustion process. The importance of proper physical movement of the fuel bed, as it effects operating efficiency, cannot be overestimated. Once determined for optimum conditions with any one installation, however, the stoker requires no radical change of adjustment provided the physical and chemical characteristics of the fuel remain fairly uniform.
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> The path followed in this movement is such that the fuel progresses from the point of introduction as fresh fuel, at the bottom of the retort, to the point of removal as refuse at the surface of the fuel bed. The introduction of fresh fuel crowds along the portions of the fuel bed just ahead and the movement, continued by the action of successive pushers, at all times is carried on with the minimum of direct contact between the burning fuel and the moving parts. Coincident with this movement the fuel passes through zones of increasing temperature below that required for ignition, yet sufficiently high to promote coking with liberation of the volatile matter. Air for combustion discharged into the fuel bed through tuyères mixes with and carries off these combustible gases and their combustion begins, along with that of the coke, as they pass through the incandescent zone at the surface. The coking process tends to close the fissures between adjacent fragments of coal and form a large mass, which in turn is subject to some disintegration as a result of action by the pushers. This may be contrasted with the absence of a 'closing up' effect in the chain-grate stoker where the blanket of fuel is spread out and transported from front to back but without other disturbance.
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> In the distribution of air to the fuel bed, the operator is thus dealing with a progressively varying resistance to the passage of air. Consequently, the quantitative proportioning of the air, as regulated by fuel-

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NOTE: In smaller type, the author has incorporated extended quotations from references made in this paper. The material is being included for further clarification.

[1] "Distribution of Air to Underfeed Stokers," by A. S. Griswold and H. E. Macomber, Trans. A.S.M.E., vol. 58, 1936, pp. 13–24.

bed resistance alone, may be other than that desirable for the most efficient combustion.

. . . curves representative of actual operating conditions with an underfeed stoker show that the resistance of the tuyères to the flow of air is of relatively minor importance as compared with that presented by the fuel bed, and is in consequence of little effect in producing a uniform air distribution. The resistance offered by any part of the fuel bed, however, is of major importance. It is in turn affected by conditions such as (1) the shape and thickness, and (2) the porosity as affected by the intermovement within itself, the coking action, and the possible formation of clinkers.

The rate of burning coal expressed in pounds per square foot of projected grate surface, per hour, within the operating range, is immediately dependent on the rate of air supply, based, of course, on the presumption that a proper fuel bed has been established and is maintained within reasonable limits of thickness and temperature. Change in the fuel bed to accompany change in coal-burning rate, on the other hand, is not immediately dependent on the rate of feeding coal, but is a cumulative process as compared to the rate of air supply.

Obviously, for a given plenum-chamber pressure the quantitative flow of air, and consequently the rate of burning, will vary inversely as the resistance offered at various points in the fuel bed, which explains why, especially under conditions of forced output, the bed may get accumulatively lighter or heavier. Without some external means of controlling air distribution, thin spots will inevitably develop in some places, while others will become exceedingly heavy. Where the fire is thin holes will be blown open, causing intensely hot blow-torch effects that may destroy the iron of the grate and induce the formation of clinkers. Eventually, the condition may extend so far that solid particles of coal or coke are blown out of the fuel bed and 'drifting' will take place. As a result, the whole fuel bed becomes physically unmanageable and the load can no longer be maintained. Coincident with this condition, an excess of air will blow through in some places while a deficiency exists in others, with an accompanying over-all loss in efficiency.

With minor modification, a comprehensive description of the progress of fuel on chain- and traveling-grate stokers can be made as clear as is the quoted material for multiple-retort underfeed stokers.

In the text which follows, operating experiences with the chain-grate, both natural- and forced-draft types; the traveling-grate; the multiple- and single-retort underfeeds; and the spreader stoker are presented.

CHAIN-GRATE STOKERS

Natural-Draft and Forced-Draft Types. These stokers have been found to be ideally suited to the burning of high-ash free-burning coals. When a coking coal is used on such a stoker, the fact that the fuel is moved essentially in one plane makes it impossible mechanically to offset any tendency of such fuels to mat over. Such matting will reduce or cut off the air supply to the matted area, allowing the stoker metal to heat, perhaps excessively, and allowing partly burned fuel to be discharged into the ash pit. Where low-ash coals are burned the protection to the stoker metal at the rear may be insufficient and if such parts as the rear shaft are not hollow and water-cooled, overheating and warping may result.

In the natural-draft type, the resistance of the fuel bed must be kept within the limitations imposed by the draft source by proper selection of the size analysis of the fuel. Obviously the forced-draft type will permit the use of a size analysis considerably higher in fines. Any condition of high furnace draft imposed by the resistance of the fuel bed will result in increased setting leakage and stack losses. In any consideration of fuel sizing the effect of segregation cannot be overlooked. Fuel which in the course of handling within the plant becomes segregated, with respect to sizes, as it reaches the stoker grates produces a fuel bed of uniform depth but widely varying resistance. The areas on which the coarser fuel is segregated will receive more than their proportion of the air supply, burn through, and expose that area to excessive radiant heat while still in the hotter zone of the furnace. Correspondingly those areas composed of finer coal and offering relatively high resistance to the flow of air will receive less of the air supply and be only incompletely burned by the time the ash pit is reached. The author has seen chain-grate surfaces which had acquired a permanent wave, attributed by the operators to segregation of fuel sizes because of the system used for delivering the fuel to the stoker hoppers. W. M. Parks[2] has discussed this matter of segregation, in part, as follows:

> Where the installation of chain grates contemplates coal storage in overhead bunkers, it is worth while to insure uniform delivery across the bunker when filling and any spouts from bunker to stoker hoppers should be so designed that they will not segregate the coal at the sides of the stoker. Unless this precaution is taken, the fires will be inefficient because of their unevenness at various points across the stoker width. Traveling weigh lorries and continuously swinging spouts are mechanical devices which practically eliminate segregation providing this fault does not exist in the storage bunker. Probably the worst condition that can exist with spout delivery is where the bunker stands at one side of the stoker and the direction of the spout is such that it throws all of the coarse coal to the far side and the fires to the near side of the hopper.
>
> Considerable ingenuity has been demonstrated by some firemen where these unfavorable coal conditions were not recognized and corrected by the management. Stoker gates have been altered to feed a deeper layer in the region where the coarse coal accumulated, thus causing the fuel bed to burn off to a more even length over the full width of the fire.

There is general agreement that the addition of moisture, in some cases to the extent of about 10 per cent by weight, improves the burning quality of the fuel. The moisture may be added in the form of water if 24 hours or more are available while the coal is in storage, or in the form of moist exhaust steam introduced into the stoker hopper if insufficient storage time is available.

During operation the tendency of ash to form side-wall clinker, which may grow and form a dam clearing the fuel from a portion of the grate surface as the grate travels to the rear, should be watched for and guarded against by providing means and access for its removal. Of course, if the owner is in a position to secure the necessary priorities design changes can be made but for the plant which finds such procedures difficult or impossible watchfulness and a slice bar will prevent the stoker metal from being overheated and burned.

Some actual cases of metal burning have been found to be caused by the operating practice of shutting off the air supply and stopping the stoker when the demand for steam decreased. Such a practice stops the cooling of the stoker metal by the air and permits overheating and burning. When the necessity for some air flow is kept in mind, minimum rates of combustion can be set at about fifteen pounds per square foot per hour below which the stoker should be stopped and burned down. The exact practice must be determined by the nature of the plant load and equipment, but it should be emphasized that the air should not be shut off completely when the load is decreasing.

The introduction of air over the fire has received attention and discussion at least as long as the author has been associated with the combustion of fuels. The purpose of the introduction of such overfire air is to provide the oxygen for the combustion of the unburned gases rising from the fuel bed and to mix the two. Experience indicates that all air should pass through the fuel bed, in order to insure as nearly as possible the complete burning out of the combustible matter in the fuel, and the excess oxygen in the leaner portions of the gas should be made available to the richer portions by mixing arches. This can be done

[2] "The Operation of Chain-Grate Stokers," by W. M. Parks, *Combustion*, vol. 11, April, 1940, pp. 24–28.

at one broad point of the rating curve but at other lower points the mixing action of the arches becomes less effective because of lower velocities and can economically be supplemented by overfire air jets. Small jets of steam can be used to study the effectiveness of each available location for air jets, these jets to be replaced by air after the best location is determined. It is increasingly obvious that higher pressures than are available from stoker wind boxes are required to form jets capable of penetrating the gas stream.

TRAVELING-GRATE STOKERS

The traveling-grate stoker differs in structural design from the chain-grate stoker but functionally it is the same type of mechanical fuel-burning equipment. The area of the grate surface open to the passage of air is small, and the air actually jets through the fuel bed at high rates of combustion. As a practical matter, the burning of steam sizes of anthracite on stokers is limited to the traveling-grate type, but this type of stoker is not limited to anthracite. Most of the causes for high maintenance applicable to chain-grate stokers are also applicable to the traveling-grate stoker.

The author made an extensive investigation of combustion of anthracite on this type of stoker in 1923, a report of which was published.[3] In these tests the ineffectiveness of overfire air introduced under stoker wind-box pressure was demonstrated as was the effectiveness of the mixing action of steam jets under 150 psi. Again, the small plant may be unable to secure the necessary priorities for refractory or water-cooled arches, but some gains may be made by air or steam jets, located experimentally, to simulate mixing arches or to increase the effectiveness of existing arches.

The unpublished results of a series of investigations of the influence of size analysis on efficiency and capacity clearly demonstrated that the maximum capacity obtainable from a given piece of equipment decreased almost in proportion to the undersize content of the fuel. The efficiency obtainable at maximum capacity decreased with increase in undersize content of the fuel somewhat in proportion to the carry-over of cinders which increased with the amount of undersize. This information is introduced in this discussion so that those who may be compelled to burn anthracites, or similar noncoking coals having increased percentages of undersize, will be made aware that the same capacity and efficiency cannot be obtained as was obtained with the coarser fuel.

With low-volatile fuels such as anthracite ignition is dependent upon the rate at which heat is received by the surface of the fuel as it enters the furnace. This has been discussed by Walter H. Wood.[4] The late Percy Nichols was engaged in an extensive study of the effect of fuel sizing and air flow on the rate of temperature penetration of a fuel bed, at the time of his death. Experience determined that anthracite must be allowed an appreciably long time for ignition penetration before rapid combustion can be forced. In furnaces without mixing arches, this requires an initial quiescent area with the bed becoming more active as it approaches the ash pit. In furnaces with mixing arches or with only one effective rear arch, it is customary to force rapid combustion in the zone just in front of the nose of the rear arch. This forcing can be enough to blow solid incandescent particles forward to aid in the initial ignition of the green fuel. This is possible without serious danger of exposing the rear section of the grate to overheating, because of the shielding action of the rear mixing arch. This shielding action cannot be simulated by air jets.

Some siftings are unavoidable, and if they are allowed to accumulate because of carelessness or oversight they may ignite and burn in the air chambers. The heat generated has been sufficient in some cases to distort the wind boxes, destroying the control of the air or actually burning the metal. It has been found at the New York Steam Corporation that an inch of grout on the bottom of the air chambers reduces the damage materially.

Where screenings or culm banks are to be used as fuel, the rate of ignition may be slowed down to the point that, at low or banked ratings in cool furnaces, ignition is difficult to maintain. In such cases, the rate at which air must be supplied to the front section to secure the maximum rate of heat penetration for a given grate speed must be determined in the field and adhered to thereafter. Mr. Nichols' data when published will serve as an excellent guide in such cases. Rapid combustion should not be attempted until that point in the travel of the grate is reached at which nearly the whole depth of the bed has reached ignition temperature.

The mixing arches over traveling-grate stokers are designed to bring the rich and lean strata of gases into intimate contact, thus improving the uniformity of the gas mixture entering the boiler. In accomplishing this result, combustion is intensified, average excess air is decreased, and furnace temperatures are raised. The higher furnace temperatures increase the rate of ignition which is distinctly advantageous with fuels of the character of anthracite, but such higher temperatures also tend to cause those ash particles which settle out in the eddies above the arches to sinter or fuse into so-called clinkers. If these lumps of ash are allowed to accumulate to a size too big to pass under the rear mixing arch or too big to pass between the end of the stoker and the rear wall, it is obvious that something will have to give when the lump reaches the constriction. If shear pins have been replaced by heavier ones than the design calls for, as has happened, the pins will not shear and grate bars may be bent or broken with a consequent fairly serious outage. Obviously, if a fuel is tried which exhibits the tendency to form such clinker, the clinker should not be allowed to grow to a dangerous size. Such accumulations can be removed with bars or can be blown off the refractory through properly located access doors before they reach a dangerous size.

THE MULTIPLE-RETORT STOKER

J. M. Driscoll and W. H. Sperr[5] have described in detail an extensive series of mechanical changes made in multiple-retort underfeed stokers in their attempts to overcome certain fuel-bed difficulties. They found that "increasing the air-entry area into the upper section of the stoker seemed to have no appreciable beneficial effect on the obtaining of high ratings." The "raising of the retort bottom along its entire length to shallow the retort and obtain greater agitation and looseness of the fuel bed failed to eliminate clinker on the tuyère row at the upper end. In order to get still more upward motion of coal out of the retorts at the upper end the upper secondary rams were made to move upward toward the tuyères as well as down the retort and lift coal on its top surface into the fuel bed." They found that this change "eliminated clinker immediately above the special upper secondary ram but in the section of fuel bed immediately following, tuyère clinker was experienced."

The final change made was to install telescoping rams—which combined the effective motion down the retort of the straight-line design and a uniform upward motion of green fuel toward the tuyères. On the test this design was capable of maintaining a uniform fuel bed over its entire length at coal-burning rates up to approximately 53 pounds per

[3] "Furnaces for Burning Small Sizes of Anthracite," by A. R. Mumford, MECHANICAL ENGINEERING, vol. 46, 1924, pp. 138–142.

[4] "Grate Temperatures, a Measure of Ignition Penetration," by W. H. Wood, *Combustion*, vol. 13, Feb., 1942, pp. 31–32.

[5] "Ten Years of Stoker Development at Hudson Avenue," by J. M. Driscoll and W. H. Sperr, Trans. A.S.M.E., vol. 57, 1935, pp. 49–58.

square foot per hour for 24-hour periods. At this burning rate, however, the fuel bed tended to become sensitive and was likely to blow off in any section.

It is known that this capacity limitation does not apply to extremely short stokers probably because of the better opportunity for operating supervision and the quicker response of the fuel bed to control measures. The exact length at which this capacity limitation becomes effective is not known from experience at Hudson Avenue; it is probably considerably shorter than the approximately 13-foot-long underfeed section of the original unit.

The foregoing selected quotations from Driscoll and Sperr's paper[5] have been presented to recall this extensive work and to emphasize the point that what are undoubtedly logical mechanical changes did not compensate for the less desirable fuel properties as the rating was forced higher and higher.

In one underfeed-stoker-fired plant the grate bars on the overfeed section burned out in comparatively short periods, and the furnace smoked during the periods in which the load changed.

After careful study and examination the production of smoke was attributed to three factors: (1) The automatic control responded too quickly for the fires, either reducing the air flow faster than the stoker speed was reduced on decreasing load, or increasing the stoker speed faster than the air supply on increasing load. Either condition resulted in a decrease in excess air and smoke on load changes. Obviously the vendor of the automatic control should be completely informed as to the characteristics of all auxiliaries on the apparatus to be controlled. (2) The stoker cam adjustments had been allowed to wear to the point at which they no longer held the proper index, and the fuel bed would change causing increased combustion rates on active parts and clinker on inactive parts. Lubrication had been rare or entirely absent. (3) The operators, who had been accustomed to another stoker, tried to hold the fuel-bed conditions the same as on the other stoker, resulting in fires which were too heavy for proper operation.

The burning of grate bars on the overfeed section could be observed from the wind box through which these bars could be seen to glow dull red. The fuel used in this instance contained 5 to 6 per cent ash. With such a fuel it should be obvious that one of the factors upon which dependence is placed for the protection of stoker iron is somewhat low. To offset this lessened protection of stoker iron, greater attention to the proper distribution of cooling air is required. If clinker or uneven fuel-bed thickness is allowed adversely to affect the air distribution, stoker metal will burn. In this instance, the operators thickened the fuel bed at the clinker pit by not grinding it down uniformly or regularly. The pit accumulation reacted physically on the remainder of the fuel bed, preventing effective operation of the mechanical parts, and increased the rate of clinker formation on the overfeed section. The operators also had the habit of closing all dampers to the overfeed section during periods of light load. Occasional failure of the automatic control on the stack damper caused it to shut and subject the fuel bed and stoker to a "soaking" heat. It was also discovered that each set of operators had different ideas about the length of pusher travel and operated the stokers accordingly. Maintenance decreased to normal and combustion efficiency improved when the obvious corrections were made.

Referring again to the paper by Griswold and Macomber,[1] the following statement is of particular interest: "The use of fuel-bed shape as a factor in regulating the distribution of air relative to the varying stages of combustion from the front to the rear of the stoker has been, and is today in most instances, the only means available for this purpose. Furthermore, in every case its establishment, irrespective of the air-distribution method available, is essential to efficient combustion. It is accomplished entirely by the operator's skill in the use of adjustments to the stoker-operating mechanism as determined by visual observation of the fire." It is interesting to note that these engineers, experienced in the operation of underfeed-stoker-fired plants, point out the dependence which must be placed on the skill of the operator.

They point out that localized burning of stoker castings and uneven burning of the fuel were traced to the high air velocities of the old small air ducts. Their advice to operators should be very helpful to those facing changes in their fuel supply, as noted in the following:

> The limit of dependable coal-burning capacity, either with or without an air-control system, is determined by the ability to keep the fuel bed in a workable condition. As previously explained, with the high air velocities occurring when operating at high combustion rates, there is a tendency to lift small particles of coke from the fuel bed and deposit them in drifts in other parts of the fire. This action, if permitted to become sufficiently aggravated, eventually causes whole sections of the fuel bed to become thin, while heavy drifts, through which no air will pass, make their appearance in other sections. The effect is cumulative, and it is soon necessary to reduce load until the fuel bed can be worked into proper shape and condition. Without an air-control system, the fuel-burning rate must be kept sufficiently low to prevent this drifting from becoming serious.
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> The most important item of expense in the operation of a boiler plant, after fuel and operating labor, is stoker maintenance. Often more can be saved by efforts directed toward minimizing it than in attaining higher combustion efficiency. It is an expense subject to many variables for a particular installation. Among these are the coal-burning rates, the accumulated total of hours in service, the temperature of the air supply, the grade of coal, as well as the skill and attention of the operator. Some of these factors are obviously determined by plant design and others are to an extent controllable in operation.

In another case, sidewall tuyères burned. The conditions at this plant indicate the advisability of knowing at least the ash content of the fuel being fed to the fires. It was noted that the coal-handling equipment caused a segregation of sizes so that the coarser fuel was fed at the sides of the stoker and the side-wall tuyères deteriorated rapidly. Other difficulties were the low ash content of the fuel and operation of a fairly high-capacity stoker at ratings little higher than a banked condition for long periods.

It was ascertained that the segregation of the larger fuel sizes at the sides of the furnace permitted higher rates of combustion to exist in those areas and the jet discharge of molten fly ash which gradually built up shutting off air through the top portion of the tuyères and transmitting heat at high temperature by conduction to the bars. Incidentally the side-wall tuyères used at the time were supplied by a local foundry and were made larger than those of the stoker manufacturer. The top locking tuyères, as observed from underneath the stoker, were heated to a pale yellow color.

Advised to procure a coal of higher ash content the operators finally told the service engineers such a coal was on the fire but it was noted that actually the grates were not dumped as often as previously although the load was twice as great.

At the very low ratings, necessitated by plant load, it was noted that the side-wall tuyères were red-hot and that opening the dampers under these tuyères made no improvement. Apparently the stoker, purchased for a maximum capacity which was not approached in regular plant operation, was too large for the low loads existing for fairly long periods. The minimum stoker speed was too slow for the rate of ignition along the front wall with this low-ash coal, allowing the fire to burn under the throat castings. A lower-grade higher-ash coal would necessitate faster operation of the stoker at low ratings. When the stoker was stopped for long periods, as was sometimes required, the fire burned back into the hopper.

It was discovered in one instance that the power supply to

the forced-draft-fan motor had been connected so that the fan actually drew air down from the fire through the stoker. Of course, the duration of this difficulty was short but such things do happen.

To correct the difficulties, the purchase of a higher-ash fuel was recommended, as well as the partial correction of conditions of coal segregation by reduction of air supply to those portions of the fuel bed receiving coarser coal, the opening of the forced-draft-fan casing to decrease the resistance when air was supplied under natural-draft conditions at low loads, and the reduction of the air supply to the throat castings to limit the rate of ignition to that possible by radiant-heat transmission alone.

The effect of heavy loads and hot furnaces has been described by J. E. Tobey,[6] as follows: "Heavy loads imposed upon the plant necessitated operating the boilers at high capacities. This resulted in excessively hot furnaces which in turn created a serious fuel problem that contributed to fuel-bed caking, clinker trouble, and excessive stoker and furnace maintenance. Furnace temperatures in excess of 3100 F were commonly encountered."

Mr. Tobey's description of what happens with an unsatisfactory fuel is well worth recalling:

> Unsatisfactory coals almost always manifested the same unmistakable signs of distress: (*a*) Caked and dense upper fuel-bed section, which was practically nonporous and of dull appearance; (*b*) lower section of fuel bed too porous and containing holes, with large clinkers above tuyère rows, fuel in the form of large blocks of coke, great excess of air, high gas velocities, and white-hot appearance; and (*c*) tube and wall slag being deposited by high-velocity jets issuing from the fuel bed, molten slag running down the bridge wall and freezing on dump plates, and slag formations at bottom of side and front walls which disturbed adjacent portions of the fuel bed, and caused hot spots, clinker trouble, and back smoking through the stoker hopper . . . . In extreme cases secondary combustion occurred in the upper furnace and first pass of the boiler which was caused by delayed mixing of the gases on account of poor air distribution.
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> When these unsatisfactory conditions, which were initiated by caking of fuel on the upper portion of the stoker, obtained, ash-softening temperature of the coal apparently became of secondary importance. In some instances, certain coals having ash-softening temperatures in excess of 2900 F caused trouble, whereas, others with an ash-softening temperature as low as 2450 F gave satisfactory results. The former caused clinker trouble and the latter did not. This apparent paradox was explained by the fact that the high-ash-fusion coals in question were strongly coking under existing furnace conditions which caused fuel-bed caking and thus reduced the effective stoker area, and thereby increased the actual burning rate on the rest of the stoker to a point where excessive temperatures were obtained under which no coal ash could resist fusion. This, in turn, caused objectionable clinker formation which had a disturbing effect upon the fires and resulted in excessive loss of stoker iron. On the other hand coals with medium-fusing ash used in the comparison above were inherently of a freer-burning nature and did not produce a caking effect of the fuel bed, released the heat in the fuel more uniformly over the entire area of the stoker, and thus prevented the occurrence of hot spots or zones of excessively high temperature. This indicates a distinct relationship between ash-softening temperature, permissible for satisfactory operation and fuel-bed porosity. . . . . Both of these types of coal giving such widely different results were in the minority and the majority of coals tested under existing load conditions whose ash-softening temperature was in the neighborhood of 2700 F were most generally satisfactory from the standpoint of slag and clinkering.
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> . . . . The angle of inclination of the upper portion of the bridge walls was such as to radiate heat back upon the underfeed portion of the fuel bed. This appeared to aggravate the caking and coking troubles on these stokers.
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> After the fuel passed through this plastic stage it became coke, and, midway down the length of the stoker, air from the tuyère rows broke through fracture cracks, causing the fuel to burn furiously above them. The upper half of the tuyère rows was too inactive and the lower half was the opposite, too active with destructive effect. Large monolithic masses of coke existed at the lower ends of the retorts and being solidly caked, it did not break down over the tuyères and come in proper contact with the air. The fuel, being in too large masses, caused large holes or crevices in the lower portion of the fuel bed, resulting in hot spots which damaged stoker iron and from which were blown molten ash and carbon, the former being deposited as tube and wall slag.

[6] "Underfeed Stokers and Coal Selection," by J. E. Tobey, Trans. A.S.M.E., vol. 60, 1938, pp. 17–24.

At another plant excessive burning of the overfeed bars was reported. Investigation showed that the fuel was very high in fines, causing large mats to form, and holes appeared quite frequently in the overfeed section. By diminishing the stroke on the overfeed bars, the fuel bed was thickened at this section to keep overfeed bars well covered. The properties of the ash permitted such operation without damage by clinker. The excessive fines caused uneven fires, blowback, and clinkering on the ash pan. When a fuel of a better size analysis was tried for one day, the results were excellent but the troubles returned when the fuel with excessive fines returned.

In Mr. Tobey's closure[7] he states: "In instances where so-called noncoking coals of lower ash-softening temperatures cause matting or surface hardening of the fuel bed, observations indicate that the cause very likely is due to the softening of the ash, resulting in a plate-like clinker, or a cementation action between molten ash and the coke particles either of which would cause the fuel bed to become impervious to air flow. The end result of this condition bears a similarity to that of coking coals having a high ash-softening temperature, a high tar yield, and a long plasticity range, in that both types of coals cause restricted air flow through the fuel bed, resulting in nonuniform burning over the grate area, hot spots, and objectionable clinker trouble. In other words, the crux of these troubles is fuel-bed porosity."

At another plant troubles developed with smoke and excessive burning of tuyères and overfeed grate bars. Much of the trouble was traced to the regulating valve on the turbine driving the stoker. When this and some minor troubles were corrected it was possible to operate normally without smoke and excessive maintenance. Under hand operation, conditions had been satisfactory, but incomplete knowledge of the characteristics of one auxiliary turbine interposed a difficulty that the automatic control could not overcome. There was some segregation and tendency of the operators to build up too heavy a fuel bed at the rear.

A. W. Thorson in a discussion[8] of Mr. Tobey's paper stated:

> At . . . a station, burning a strongly caking coal on stokers with adequate agitation, segregation occurs in certain bunkers because of limitations imposed by the coal-handling machinery. It was difficult, even with zoned-air control, to keep as uniform fuel bed as desired. Although this in itself is not a serious operating difficulty, it was observed that stoker iron loss was concentrated at the sections receiving the coarser coal. As an experiment the crusher was adjusted to reduce the coal size from $1\frac{1}{2} \times 0$ in. to $\frac{3}{4} \times 0$ in., with the result that the fuel beds appear uniform and stoker iron loss is slightly reduced.

THE SINGLE-RETORT UNDERFEED STOKER

The single-retort underfeed stoker may be considered as one unit of a multiple-retort stoker. Certain differences are obvious but the principal one is that moving grates take the place of tuyères at the side of the retort, and longitudinal motion of the fuel is translated to lateral motion with the ash discharge at the sides rather than the end. Because of this change in direction of flow emphasis is placed on the proper motion of the parts to provide correct air distribution and progressive feeding and

[7] "Underfeed Stokers and Coal Selection," by J. E. Tobey, Trans. A.S.M.E., vol. 60, 1938, pp. 17–24.

[8] Ibid., p. 368.

burning. In addition to the motion of the grate bars for uniform lateral distribution the pusher blocks in the retort must be adjusted for proper longitudinal distribution. The required motion of the parts varies with the sizing of the coal, and the setting for a fuel high in undersize will differ materially from that for a coarse fuel.

In any mechanism, on the surface of which rests a granular solid material, operating with relative motion between the parts some sifting of the finer material between the parts will take place particularly where air spaces are also provided. The small wind box of a single-retort stoker is not designed for storage of fines, and when it is realized that one plant failed to remove siftings over a 6-month period, it can be readily understood that uniform air distribution could not have existed even though conversely it may be surprising that the siftings were so few that the stoker could still operate. At this same plant, the fuel was a medium low-ash coal and the importance of air distribution for cooling stoker iron was relatively greater than it would have been with a moderately high-ash coal. Here also, the operator so far forgot himself as to neglect to raise the dump plates after the ash had been dumped. The stream of partly burned fuel which tried to complete its combustion in the ash pit was pretty successful in burning stoker iron.

At another plant the automatic control had been set to maintain a balanced draft in the furnace when a definitely negative pressure of about 0.15 in. was desired. The fine coal became plastic at the surface and matted, and grate bars burned through. When the furnace draft was set for the proper value and the automatic control adjusted to maintain it the high maintenance became reasonable maintenance.

At another plant, it was found that attempts were being made to burn a coal containing about two per cent ash, whereas the specified coal was one containing about seven per cent ash. Grates burned because of the absence of any protective layer of ash between the metal and the "hot" coal. The cooling power of the air alone was insufficient for protection. Satisfactory conditions were restored by a higher ash content obtained by blending of fuel from a different source.

Where the fuel ash is medium low, distribution of coal and air must be good to compensate for the lesser quantity of noncombustible available for protection from heat. In stokers of the underfeed and moving-grate types fresh fuel is not introduced on top of a layer of partly or completely burned fuel, as is the case with hand firing, but moves progressively from the point of entry to the ash pit so that the only available protection is obtained from the ash in the fuel actually undergoing combustion.

THE SPREADER STOKER

This simple mechanical device for firing solid fuel is enjoying deserved popularity and active demand. If the dearth of available information on troubles is an acceptable indication of satisfactory performance, then this stoker, now in widespread enough use to be representative, is successfully meeting the demands imposed upon it. In fact one of the few difficulties found with this type of stoker is inherent in its ability to meet the demand. Apparently it is so easy to raise the firing rate that there has been found, in some installations, a tendency to raise the firing rate above the capacity of the utilizing equipment to remove the products of combustion. When this is done the furnace pressure becomes positive and the hot gases will escape from the furnace through any available openings. One of these openings is that through which the fuel is introduced and in which the spreader mechanism operates. Hot gases burn the metal of the spreader mechanism under bad conditions, or warp it badly under milder conditions of positive pressures in the furnace. With some fuels the decrease in the amount of air through the fuel bed which accompanies positive furnace draft will cause some slagging of the ash on the grates.

The danger of discharging hot gases through the stoker mechanism can be avoided by automatic control of fuel feed, air supply, and furnace draft. In one case repeated instances of trouble arose from the attempt to control these elements by hand. The reason for the difficulty of operating by hand control is the low resistance of a thin fuel bed on the grates and the rapid response of the mechanism to a change in adjustment. Some manufacturers prefer not to sell these stokers unless automatic control is provided.

Where spreader-type stokers are installed in plants accustomed to hand firing, it is sometimes difficult to secure a change in fuel sizing from the large sizes desirable for hand firing to the commercial $^3/_4$-in. nut and slack which is more desirable for the spreader. The feeder mechanism of spreader stokers is designed for the smaller sizes and, although it will successfully handle occasional lumps of 2 to 3-in. size, the mechanism should not be called upon to act as a coal crusher. Shear keys are provided to protect the mechanism, but the replacement of these with heavier keys has been known to occur. The drive mechanism becomes overloaded and wear becomes accelerated.

The larger lumps have a longer trajectory and will tend to pile up at the sides and back of the grate. Such piling up of the fuel encourages clinker formation which is troublesome with any type of grate and may result in burned metal with some types. The simple easily adjustable controls permit the firemen to place the fuel at the desired point on the grate so that uneven distribution has been corrected by alert firemen in five to fifteen minutes.

If ultrafine coal is used on a spreader stoker, more of the fuel is carried in suspension by the combustion gases and increased cinder losses result.

It is obvious that, even if the coal size is correct, the operator may fail to keep the speed of the spreader adjusted properly so that uneven distribution results. Under such conditions, the distributor assembly may be overheated by a heavy fire at the front, and slagging on grates or refractory walls, or brickwork erosion, may be caused by heavy fires at the sides or rear.

CONCLUSION

The fact that the simple causes of high maintenance which have been mentioned in this paper actually occur, although elementary in character to fuel engineers, is sufficient reason for their presentation. If repeated instances of the same simple causes had not been found, the proper interpretation would have classed the instance as an isolated one, but repeated instances have been found and, therefore, the causes should be discussed.

It is not to be supposed that any fuel may be made to work satisfactorily on any stoker. The several types of stokers mentioned in this paper are handling coals of fairly broad ranges or characteristics and handling them successfully. The material in this paper is intended to cover the variations in stoker operation which will be required when the customary fuel becomes unavailable for the period of the emergency. Operators to avoid high stoker maintenance must carefully watch the effect of any change in fuel characteristics and use their ingenuity to insure that the stoker iron is properly cooled by the combustion air and where suitable protected by a layer of porous ash. Extra attention and observation is required but is well within the capabilities of American operators. Control equipment should not be expected to do the impossible but should be fitted to the equipment it is to control. Good combustion need not be sacrifiecd when avoiding high maintenance if the essentials of each are kept in mind.

Analyzing Heat Flow in CYCLIC FURNACE OPERATION

New Method Simplifies Determination of Economic Insulation Thickness

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THE determination of optimum thickness of insulation for maximum economy in the operation of heated equipment under steady-state conditions has long been an established practice. In the case of problems involving periodic or intermittent operation, however, the methods of solution previously available have not been found entirely practicable because with unsteady-state heat flow a number of variables are brought into play which introduce many and complex factors.

A new tool of investigation, the "heat-and-mass-flow analyzer," shows promise of fulfilling the requirements as a method of solving problems of the latter type without the shortcomings of methods previously available. This analyzer, developed by V. Paschkis at Columbia University, is based on the analogy between certain electrical circuits and transient heat-flow phenomena. The method and apparatus have been described elsewhere.[1] It is the purpose of this paper to discuss the determination of heat flow under unsteady-state conditions and to report the comparative results of a heat-flow problem, worked out both by the conventional direct-test method and by the new analyzer.

The importance of the analyzer is due to the fact that the design of heated equipment for maximum economy of operation under unsteady-state conditions requires the determination of the optimum thickness of insulation which in turn hinges upon the accuracy of the determination of the unsteady-state heat flow. The analyzer accurately determines this heat flow.

Economical operation of heated industrial equipment is to a large extent a matter of controlling the amount of heat utilized in a particular heating operation. In any fuel-fired equipment using coal, gas, or oil, economy of operation requires that the maximum amount of heat be extracted from the fuel. This is a matter of combustion technique. Regardless of the efficiency of combustion, however, there is an additional element of cost, shared by fuel-fired and electrically heated equipment alike. That element is the heat lost through the wall structure.

Control of heat loss through the walls of heated equipment is the function of thermal insulation. Proper use of thermal insulating materials, however, does not mean the complete elimination of heat loss or even reducing it to a minimum, but rather reducing the loss to a point where the saving in heat loss (as represented by the cost of the heat lost) will be consistent with the cost of the insulation.

As the thickness of insulation is increased, the cost of heat loss per unit of time is, of course, decreased but the cost of insulation per unit of time (initial cost multiplied by per cent fixed charges) is increased. Obviously, the thickness at which the sum of these two costs is lowest is the most economical thickness.

For flat surfaces this thickness may be determined[2] from the equation

$$X = \sqrt{\frac{ak}{b}} - Rk$$

in which X is the most economical thickness, k is the conductivity, b is the cost of insulation per inch thickness per year, R is the sum of the resistances of all other elements in the construction, and

$$a = \frac{Y(t_0 - t_a)M}{1{,}000{,}000}$$

in which Y is hours of operation per year, t_0 is inside temperature, t_a is temperature of surrounding air, and M is the value of heat in dollars per 1,000,000 Btu. This formula applies only when the time of continuous operation is sufficiently long to make the amount of stored heat negligible with respect to the total heat loss.

The economical application of insulation under such steady-state conditions, i.e., the process of heat flow where the temperature at any given point in a wall structure is independent of time, is, as was stated before, a long-established engineering practice. The heat flow through a given wall structure is determined on the basis of equilibrium temperatures and conductivities of the materials involved. The heat storage of the wall structure is a factor only in the initial heating up of the wall and has no bearing on the heat flow, once a steady-state condition is attained.

As distinguished from "steady state," "unsteady state" refers to the process of heat flow where the temperature varies with time. The characteristic behavior of temperature and, consequently, of heat flow in the unsteady state is due to combined effect of thermal conductivity and heat storage. Heat storage, in turn, is a function of density and specific heat.

The influence of heat storage can best be illustrated by considering the two limiting cases for a wall of finite thickness; (1) with no heat storage, and (2) with infinite heat storage. In the case (1) of no heat storage, the wall would behave the same under unsteady-state as under steady-state conditions. In case (2) the heat input would continue indefinitely with no loss from the cold surface.

Practically, the influence of heat storage can be observed as follows: When a furnace is started from a cold state, there may be no noticeable temperature rise or heat loss from the outside

[1] "A Method for Determining Unsteady-State Heat Transfer by Means of an Electrical Analogy," by Victor Paschkis and H. D. Baker, New York, N. Y., Trans. A.S.M.E., Feb., 1942, pp. 105–110.

Contributed by the Heat Transfer Division for presentation at a Meeting of the Metropolitan Section, New York, N. Y., February 24, 1943, of The American Society of Mechanical Engineers.

[2] "Heat Transfer Through Insulation in Moderate- and High-Temperature Fields; Statement of Existing Data," by L. B. McMillan, Trans. A.S.M.E., vol. 48, 1926, p. 1269.

surface for a considerable time after the inside surface has reached its final temperature. On the other hand, with a furnace that has been in operation for a period of time at a given temperature, the outside temperature may remain practically unchanged for a considerable time after the heat has been turned off and the inside surface temperature has dropped appreciably.

For the economical application of insulation on heated equipment under unsteady operation, it is necessary to determine the average heat flow through the structure. The temperature at given points in the structure will vary in accordance with temperature variation at the hot face, and the average heat flow will be a function of the average temperature gradient through the structure. Assuming that the hot-face temperature variation is the same for each cycle, if the cooling time is sufficiently long to eliminate any effect of one cycle on a succeeding one, the average flow for any cycle will be the same. However, if the cooling time is sufficiently short for one cycle to influence the following one, the average heat flow of a typical cycle (after cyclic equilibrium is attained) is used as a basis for economic calculations.

From the foregoing it is obvious that the determination of wall temperatures and heat flow through a wall under unsteady conditions it not as simple as it is for steady state. The solution of these problems must, for practical reasons, be kept as simple as possible, while meeting the requirements of accuracy.

METHODS OF SOLVING UNSTEADY-STATE HEAT-FLOW PROBLEMS

Mathematical determination of the effects of varying conditions of temperature and heat flow for a given oven or furnace-wall construction would be desirable. However, this would involve the application of a solution of Fourier's differential equation of heat flow to the particular problem under consideration, and so far, it has been possible to do this only for a few simple constructions and conditions.

While the differential equations can readily be written for most cases, their solution has frequently not been accomplished. Moreover, where the general solution is known, tables for the ready numerical evaluation of actual cases are not always available. This is especially true for composite walls which are usually encountered in practice.

The graphical method of solving such problems is comparatively simple, which is a point in its favor. However, the accuracy of any method of solution is an inverse function of the degree of simplification. The assumptions necessarily made and the limitations placed on variable functions in the graphical method do not make for extreme accuracy. Though simple, the method is time-consuming, somewhat out of proportion to the accuracy obtained, and not satisfactory for cycling operations.

Direct testing requires the best of test equipment and most careful technique to obtain accurate results. It is generally very difficult to duplicate service conditions in the laboratory, exactly, or to get accurate measurements in the field. At best, a single test would usually yield information applicable to only one set of conditions, applying to one structure. This is especially true in the case of cyclic heating. A sufficient number of tests to produce information of practical value to the furnace designer or operator would, in most cases, prove prohibitively lengthy and expensive.

As a result of the difficulties and inaccuracies experienced with such methods of solution, the practice has been to make broad assumptions based on steady-state conditions, such as assuming, in the case of the furnace wall operating under cycling conditions, that the heat flow will be some percentage of the steady-state flow. The percentage selected is based on individual judgment tempered somehow or other with experience, the result of which can never be proved conclusively. The disadvantage of this approach is obvious.

The new tool of investigation, the heat-and-mass-flow analyzer, shows promise of fulfilling the requirements as to a method of solution without the shortcomings of these other methods.

Although the use of analogous electrical circuits for the investigation of transient-heat-flow problems has been described elsewhere,[1] a brief review of the basis and procedure follows:

One-dimensional heat flow in a solid body can be represented by the flow of electricity in a circuit consisting of resistors and condensers. There is a perfect analogy between the two systems as follows:

Electrical capacity	Thermal capacity
Electrical resistivity	Thermal resistivity
Voltage	Temperature difference
Current	Heat flow per unit of time

In order to investigate a heat-flow problem, the body subjected to heat flow is considered in sections. Each section is represented by an electrical resistor and a condenser. After the analogous circuit has been set up, its ends are subjected to a voltage-time curve corresponding to the temperature-time curve in the heat problem.

Voltage and current time measurements in the body yield, by simple conversion methods, the desired temperature and heat-flow time curves at points within the body.

One important feature of analogous electrical circuits is the possibility of applying a variable time scale. For example, the equivalent investigation of a heat-flow operation actually lasting a number of hours, e.g., 24 hours, may be arranged so as to require only several minutes, or conversely, an operation lasting only a few seconds can be stretched to last several minutes.

In view of the possible advantages offered by this method, a typical furnace-wall construction was examined by direct test and with the analyzer in order to demonstrate the practicability of the electrical analyzer as a method of solution for heat-insulation problems.

The direct test was carried out in the Johns-Manville laboratories while the test on the analyzer was made in the heat transfer research laboratory, department of mechanical engineering, Columbia University, under the direction of V. Paschkis.

DIRECT TEST VERSUS HEAT-AND-MASS-FLOW ANALYZER

The problem chosen for a comparison between the electrical analyzer and direct test was as follows:

A 9-in. insulating refractory brick wall the cold surface exposed to air at a temperature of 100 F was subjected to cyclic heating in the following manner:

Heating as rapidly as possible to a hot surface temperature of 1900 F.

Holding this hot surface temperature constant until eight hours from the start of the cycle.

Allowing the wall to cool for 16 hours.

Repeating the foregoing heating and cooling schedule until the temperature-time curves for various points in the wall were identical for two consecutive cycles.

For cyclic equilibrium, the following information was required:

Total heat input over 24-hour period.

Average heat flow.

Temperature-time relations for various points in the wall, including the cold surface.

In addition, the heat input per cycle, for all cycles up to and including the equilibrium cycle, was desired.

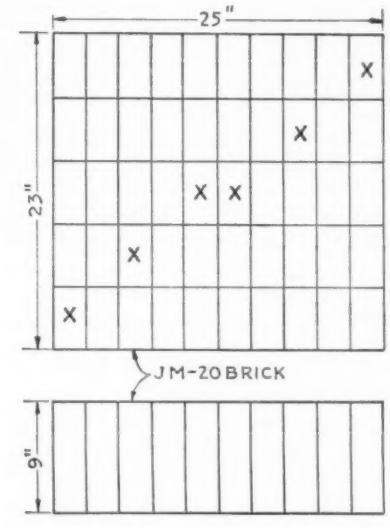
DIRECT TEST

The direct test was performed on a panel of JM-20 brick, built up in the wicket of a kiln in the Johns-Manville research

laboratories. Owing to the time and expense involved in conducting a precise test of this nature, it was decided to forego many of the refinements necessary for maximum precision.

The dimensions of the wicket were $26\frac{1}{2} \times 24 \times 12$ in. The brick were laid on their $2\frac{1}{2} \times 9$-in. sides making a panel 9 in. thick. The panel was 5 brick high by 10 brick wide, laid up in JM No. 1626 cement, making a panel approximately $23 \times 25 \times 9$ in. The spaces between the sides and top of the test panel and the wicket were filled in with pieces of the JM-20 brick. The panel was constructed by a shop mason following usual construction procedure.

Five thermocouples were placed in each of six brick in the following positions: One at the center of the hot surface, one at the center of the cold surface, and three others spaced equally along a line between these surface thermocouples. Thus, the five thermocouples attached to each brick were equally spaced throughout the thickness of the test panel. The brick to which thermocouples were attached were positioned roughly on a diagonal of the test panel as indicated by the x's in Fig. 1, which illustrates the test panel and the method of applying the thermocouples. The thermocouples were No. 22 B&S gage chromel-alumel, asbestos-insulated.



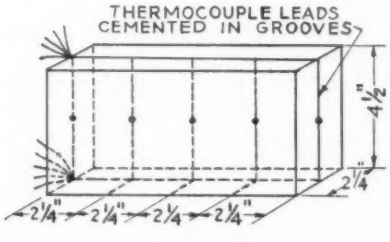


FIG. 1 TEST PANEL AND METHOD OF APPLYING THERMOCOUPLES

A draft gage was installed in the kiln stack, and, by means of a damper adjustment, the stack draft was maintained as nearly as possible at 0.05 in. of water during heating. During the cooling period the damper was closed.

The kiln was heated by gas until a temperature of 1200 F to 1400 F was reached after which oil was used. The kiln temperature was brought up to 1900 F as rapidly as possible and was then held as near that temperature as possible, by manual adjustment of the burners, until eight hours from the start of the cycle. The burners were then turned off and the kiln allowed to cool for 16 hours. During the cooling period, the burner ports were closed in order to minimize cooling of the wall from the inner surface. Air leakage from other sources, however, resulted in considerable cooling from the inner surface of the test panel. Cycles of 8 hours' heating and 16 hours' cooling were continued until cyclic equilibrium was attained.

Thermocouple readings were taken just before the test was started and every 30 min throughout the test, the exact time of each reading being recorded.

The third and fourth cycles were identical within the limitations imposed by variations in fuel control and surrounding conditions.

HEAT-AND-MASS-FLOW ANALYZER

For the test with the electrical analyzer, a time ratio 1:200 was selected. Hence, the circuit was so set up that one hour (3600 sec) of thermal flow was represented by 18 sec of electrical flow. The method of calculating the time ratio is described elsewhere.[1]

Based on these calculations, the electrical circuit as shown in Fig. 2 was found to represent the test wall. The capacitances (representing the heat storage) were held constant during the test because the change of the specific heat with temperature was not sufficient to warrant changing them. The resistances, however, were changed as the temperature in each section changed. The resistance values in Fig. 2 therefore are only indicative of the magnitude; the actual values covered a range of approximately 15 per cent above and below these values.

A potential difference of one volt represented a temperature difference of $8\frac{1}{3}$ F; thus 2000 F were represented by 240 volts. The time-temperature schedule for the hot surface in the direct test was followed for the hot surface on the analyzer by adjusting manually in short intervals (minimum interval 2 sec, maximum, 18 sec) the voltage imposed on the system during the heating period and by adjusting a variable "leak resistor" during the cooling period. The "leak resistor" is the variable resistance shown in Fig. 2.

A current of one milliampere represented a heat flow of 2160 Btu per sq ft per deg F per hr. By reading the two milliammeters shown in Fig. 2, the heat flow entering the hot surface and the heat loss from the cold surface were determined.

RESULTS

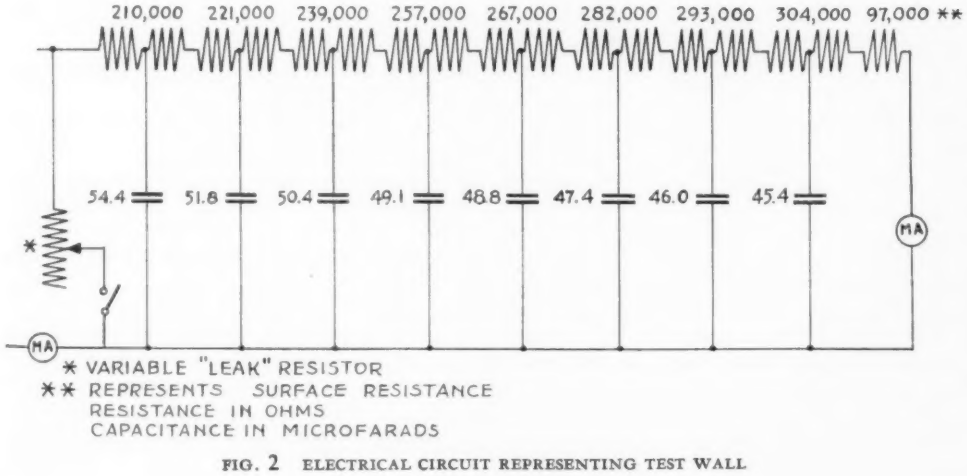


FIG. 2 ELECTRICAL CIRCUIT REPRESENTING TEST WALL

The correlation between the direct test and the electrical analyzer is shown in Fig. 3, by plotting temperature versus time for various points in the wall. These points are at the hot surface, $2\frac{1}{4}$, $4\frac{1}{2}$, and $6\frac{3}{4}$ in., respectively, from the hot surface, and at the cold surface. The solid curves represent the direct test; and the points, the electrical analyzer. The change in the temperature wave as it passes through the wall is clearly demonstrated. It is to be noted that the amplitude of the wave decreases with the distance from the hot surface

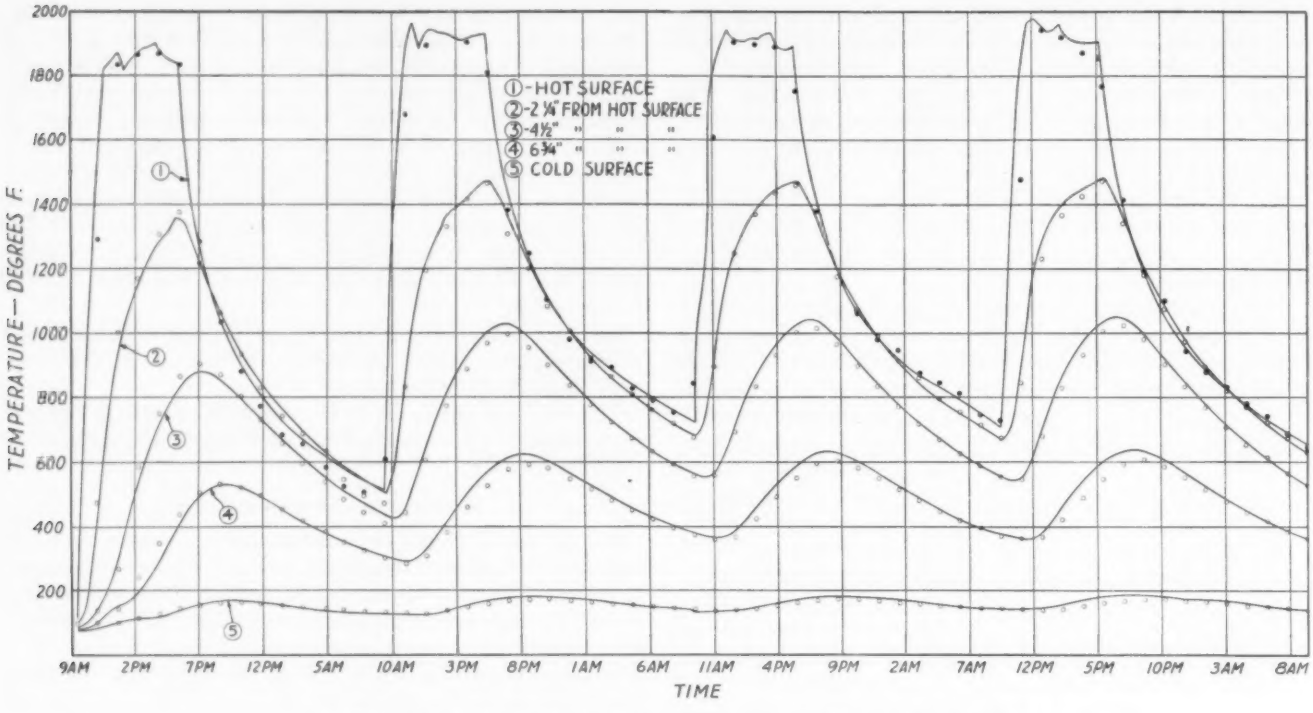


FIG. 3 CORRELATION BETWEEN DIRECT TEST AND ELECTRICAL ANALYZER

and the peaks lag increasingly behind those at the hot surface.

The fourth cycle is found to be practically identical with the third cycle and therefore cyclic equilibrium can be considered as reached at the end of the third cycle.

As previously mentioned the time-temperature schedule applied to the hot surface in the direct test was applied to the hot surface on the analyzer. The slight variation found between the two is a result of the manual control of the analyzer voltage representing the hot-surface temperature. Any variation found between the direct test and the analyzer at other points in the wall can be ascribed mostly to this variance at the hot surface.

As the test panel in the direct test formed part of the kiln wall, it was not possible to measure the heat input into the panel. Also it was not practical to use a heat-flow meter on the cold surface in view of the comparatively small area. The heat flow for the equilibrium cycle was therefore calculated from the temperature drop between the hot-surface thermocouple and the nearest thermocouple in the panel, the thermal conductivity at the mean temperature between these two thermocouples, and the distance between them. Values of heat flow calculated for half-hour intervals were plotted against time. The area under the curve, as measured with a planimeter, minus the area under the zero axis gave the net heat flow into the hot surface. This quantity for the equilibrium cycle must equal the heat flowing out of the cold surface of the wall.

The calculated heat flow for the equilibrium cycle in the direct test was 3350 Btu per sq ft which compares with 3486 Btu per sq ft as measured with the analyzer.

TIME REQUIRED FOR TEST

The time required for the test can be broken down into three parts, i.e., preparation, test, and evaluation.

In the direct test, the time required to perform a given test is not under control, but depends upon the structure of the test wall and the heating schedule. If the conditions are such that temperatures change very rapidly, difficulties of measurement and control may be considerable. On the other hand, if conditions result in slow temperature changes, or if a long time is required to reach cyclic equilibrium, a test may require uninterrupted attention for several days or weeks.

For this test, the preparation required about two days, the taking of data required continuous attention for nearly five days, and calculation and evaluation of data required about five days, making a total of 12 days for the entire test.

For the electrical analyzer, the preparation consisted of computing the electrical analogy, setting up the circuit, i.e., making the desired connections, running pilot tests, and training the operators. This required a total of 20 hr. The test consisted of running through the "24-hour cycle" 4 times to insure reaching cyclic equilibrium. Inasmuch as the time scale was such that 18 sec represented one hour in heat flow, 432 sec represented 24 hours. Hence, the four cycles took $4 \times 432 = 1728$ sec, or approximately 30 minutes. The time required for evaluation was 20 hours.

DETAILS OF EQUIPMENT REQUIRED

In addition to the test structure, with burners or heaters, the direct test would generally require the following equipment:

1 Means of controlling accurately the heat input to the furnace.

2 Carefully calibrated thermocouples or resistance thermometers for measuring temperatures.

3 If thermocouples are used, they should be referred to an iced cold junction.

4 Accurate potentiometer or bridge, the choice depending upon whether thermocouples or resistance thermometers are used.

5 Switching arrangements for choosing the thermocouple or thermometer to be read.

6 Accurate clock, stop watch, or interval timer.

(If temperature changes were rapid, it would be necessary to provide automatic means of selecting and recording the temperatures indicated by the thermocouples or thermometers. If many temperatures were to be recorded simultaneously, the amount of such equipment would become large and the cost would be great.)

The electrical analyzer as a unit comprises the following:

1 Multiple groups of various sized condensers and variable resistors.

2 Bus circuits and switching facilities for combining the condensers and resistors in various arrangements.

3 A well-regulated vacuum-tube power supply with variable voltage and current control.

4 A vacuum-tube-operated integrating milliampere-minute meter.

5 Vacuum-tube-operated multipoint recording voltmeters.

6 Milliammeters for measuring instantaneous current flow.

7 A voltmeter for measuring the input voltage.

8 A time meter.

Thus the electrical analyzer was immediately adaptable to this problem, as it would be for innumerable other problems, without need of extra equipment.

LIMITATIONS

Direct Test. In order to determine the manner in which temperatures and heat flow vary from cycle to cycle in the direct test, as well as to obtain exact duplication of cycles after cyclic equilibrium is reached, it is necessary carefully to control the heat input to the furnace during the heating-up period, the temperature of the furnace (or the hot surface of the test panel), after a predetermined temperature has been attained, and the surrounding conditions. Accurate heat-input and temperature control are possible in a well-designed test but would be expensive. Reproducibility of the temperature of bodies, to which the cold surface might radiate, would require a room in which these factors were under control. This would involve special construction.

In the test described the heat input was adjusted manually. Also, the test panel was installed in the wicket of an existing kiln, so that control of external conditions was not possible.

Temperatures of hot and cold surfaces, and of points within the wall structure, as well as furnace temperatures, would usually be measured with thermocouples, although resistance thermometers also might be used. In either case, the accuracy of the final results of test would be dependent upon the accuracy with which thermocouples or thermometers were calibrated.

The calibration of the thermocouples may change during the course of the test. This may be detected by a recalibration after the test is completed, but the correct calibration at any intervening time would still not be known.

In the present test, the holes in the brick into which the thermocouple wires were drawn were quite carefully drilled, but since the test was not designed for any great degree of accuracy, the exact locations of the thermocouple junctions were not determined. This would require careful cutting of the brick, after completion of test, to expose the junctions for measurements.

The measurement of time was not very critical. Temperature changes were slow enough so that 30-min readings of the thermocouples, recorded to the nearest half minute, were sufficient. In many tests, however, it would be necessary to follow rapid temperature changes. In such cases, automatic temperature-recording instruments would be required.

In general, a test on any given construction will yield information applicable to a very limited number of cases. The time and expense involved in such a test would usually be so great as to limit seriously the number of tests, and, therefore, the amount of useful information obtained. The three cases most easily realized in the laboratory are the sphere, the cylinder of infinite length, and the wall of finite thickness but of infinite extent. While considerable fundamental information may be obtained from these three idealized cases, it is usually difficult to apply such information to a practical construction.

In the present test, the thermal characteristics of the walls of the kiln were different enough from those of the test panel to result in considerable variation from the conditions of an infinite wall. Data from the two center brick of the panel, where infinite wall conditions were most nearly realized, were used.

Analyzer. The main limitation of the analyzer is the need to know the physical constants involved. The analyzer does not yield any answer better than the constants (specific heat, density, thermal conductivity, film conductance) applied. This limitation is not too serious for several reasons, as follows:

1 The physical constants are fairly well known, perhaps within a tolerance of the plus or minus 10 per cent. Recent investigations, conducted in connection with the work of The American Society for Testing Materials, Committee C-8, indicate that it is now possible to determine the thermal conductivity of refractory materials to within this accuracy. In the past, accurate specific-heat values for insulating refractories have not generally been available. However, a new apparatus has been developed with which such values may be determined with a very satisfactory degree of accuracy. It is proposed to publish a description of this apparatus in the near future.

2 The method allows determination of the relative influence of the different variables in a short time. Then, if necessary, a more exact determination of the most important properties can follow. Theoretically further limitations exist in the selection of time ratios. Long duration of experiments (small time ratios) call for extremely high capacities and resistors, possibly higher than available. When the duration of the experiments is very short it is difficult to make many changes in the settings of the voltage, etc.

CONCLUSIONS

The electrical analyzer gives results which check closely with the direct test. These results are obtained in much less time and without the need of building an actual test wall. The mechanical problems, with regard to calibration and manipulation of test equipment, are considerably reduced, which makes for much more extensive investigation as well as ease of reproducing results.

Applications. There are numerous applications of insulation, involving unsteady-temperature conditions, where the electrical analyzer can be of considerable service. Among these are:

1 As indicated in this paper, the analyzer can be used to determine the average heat flow through a great variety of wall thicknesses and constructions in order to establish which is the most economical thickness and combination for a particular application.

2 In many insulation applications it is necessary to protect materials having high resistance to heat flow, but low temperature resistance, with materials of higher temperature resistance but lower efficiency. The ability of the analyzer to determine specific temperatures under unsteady heating operation enables the use of lesser thicknesses of the higher-temperature materials as compared with steady-state conditions.

3 In many applications of annealing furnaces, etc., it is necessary to control the cooling rate in accordance with the characteristics of the material being handled. A required cooling schedule can be met by a proper choice of materials and combination for the furnace wall which would give a heat loss through the wall to coincide with the cooling schedule. A specific wall construction would obviously be a function of the load in the furnace as well as the cooling schedule.

4 Another problem in connection with cyclic heating operations is to obtain operation of automatic temperature controls without undue hunting. This involves selection of a wall structure of such insulating value and heat capacity that it does not unduly oppose operation of the automatic control and cause it to function too often or with too great a temperature swing.

The ADVENTURE *of* TOMORROW

By CLARENCE E. DAVIES

COLONEL, ORDNANCE DEPT., CHIEF CONTROL BRANCH, OFFICE CHIEF OF ORDNANCE, WAR DEPARTMENT, WASHINGTON, D. C., AND SECRETARY (ON LEAVE), THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

IT IS a high honor to be permitted to participate in this wartime commencement at the Carnegie Institute of Technology. It is, therefore, a welcome opportunity to pay tribute to the man whose beneficence made your Alma Mater possible and also made available the great Engineering Societies building in New York, the capitol of the engineering profession whom in peacetime I have the privilege to serve. It is also an opportunity to pay tribute to the quality of your faculty and the wisdom and leadership of your president. That a log and Mark Hopkins are all that is needed for an engineering school is of course a fallacy; without true teachers the best engineering laboratory is but a hollow shell.

If I were in your place today, I am sure that my mind would be on the exciting times, the uncertainty, and the adventure of the future just ahead. May I join that realm of thought and talk with you about some of the things that loom large in the present and will have a profound effect on your future? The adventure of tomorrow is fraught with risks. The issue hangs on unforeseen events. The security of the future depends on the wise exercise of great responsibilities.

As a nation we have enjoyed for generations a physical security, a moral security, and a religious security enjoyed by no other nation. By the acts of unprincipled rulers these securities are now threatened. Today, we have been at war over a year in a concerted attempt with our allies to regain these securities and to establish in the world the basis that will insure for all peoples security of mind and liberty of thought, action, and worship, the heritage that our nation bought and paid for in previous struggles and now to be maintained only by greater sacrifices and struggle.

The impact of this war on our daily life and its far-reaching results on the life and habits of the peoples who survive it are almost beyond comprehension.

WE DARE NOT UNDERESTIMATE OUR ENEMIES

Our enemies are prepared and have been so for some time. They are purposeful and ruthless, and we dare not underestimate them. They will not fall in the face of the mere mass of productive might of this nation. They must be fought and conquered on the field of battle.

Germany has survived three years of war, and Europe and a part of Russia are now at her feet. Her armies are largely intact despite some recent serious reverses. Her resources have increased manyfold with her conquests, and her productive capacity has grown with the added machines and skills of captured lands. Germany has been on a war economy since 1932, and her people have been inured to long hours of arduous work and the lack of many of the things we regard as essential. Her generals and soldiers were trained in mass maneuvers simulating battle conditions and have developed now into seasoned veterans as a result of the bloody campaigns in Europe and Russia. The German people and the German armies now are being keyed to greater efforts in their struggle by the obvious knowledge of the fate in store for them on the day of reckoning.

As for Japan, may I summarize from a recent publication some of the words of Joseph Grew, our Ambassador to Tokyo from 1932 until we received that barbarous stab in the back on December 7, 1941:

"The Japanese are united, they are trained, they are frugal, they are fanatical, and at least in war they are totalitarian. Their concentrated political, economic, and military power can be used swiftly and ruthlessly by despots who do not stop to explain. The Japanese leaders do think they can and will win. They are counting on our underestimates, on our apparent disunity before the war, on our unwillingness to sacrifice, to endure, and to fight. The Japanese may not intend to take San Francisco. They do intend and expect to conquer Asia. Then later they would use the billion men of an enslaved Asia and all the resources of the East to strike again. Their well planned campaigns southward were brilliant accomplishments. We now face not only Japan but Japan and Japan's conquests. These conquests are greater than we have permitted ourselves to realize. They include more than ten times the area and three times the population of the Japanese Empire as it stood a year ago."

Discussing Germany and Japan Mr. Grew says, "I know the Germans well; truculent, and bullying, and domineering when on the crest of the wave; demoralized in defeat. The Germans cracked in 1918. I have steadfastly believed and I believe today that when the tide of battle turns against them as it assuredly will turn, they will crack again. I know the Japanese intimately. The Japanese will not crack. They will not crack morally or psychologically or economically, even when eventual defeat stares them in the face. . . . Only by utter physical destruction or utter exhaustion of their men and materials can they be defeated. . . . That is what we are up against in fighting Japan."

OUR WAR PREPARATIONS ARE PROGRESSING

These are some of the characteristics of our enemies. To defeat them in battle our armies and navy must be trained and equipped with the best of weapons and kept supplied with the myriad items a complex mechanized force needs. This work includes tremendous problems of transportation. Above all, the morale of these men must be maintained at a high level by the united support of those who work at home. This task provides a place for each civilian. No one group or class or profession can do this or claim full credit for final success.

Good progress has been made. The President has reported that five million men are now in the Army and one million five hundred thousand in the Navy. One million men are now overseas, carried there with their weapons and supplies through dangerous waters and delivered in battle order. This accomplishment in the first year of active war is the result of a long period of planning and review during the years of peace and not merely the result of an acceleration starting with the declaration of an emergency in 1939.

Great strides in all phases of war preparation have been made. To be specific I wish to mention one phase, namely, ordnance for the Army. It has been my privilege for over two years to have served as a Reserve Officer in the Ordnance Department of the Army, and a summary of a few of its activities since the start of the emergency will reveal, I believe, the scale of the present effort and some of the accomplishments.

Commencement address at the Carnegie Institute of Technology, Pittsburgh, Pa., Dec. 20, 1942.

WHAT THE ORDNANCE DEPARTMENT IS DOING

A great many people are under the misunderstanding that the word ordnance connotes merely the manufacture of rifles and big cannon. The general function of the Ordnance Department is to develop, design, manufacture, procure, supply, store, and maintain Ordnance matériel and to train personnel for field duty. This responsibility covers the whole catalog of Army weapons, from side arms to cannon, and the ammunition they shoot, the development and procurement of submarine mine equipment, complicated optical devices needed for sighting and range-finding, combat vehicles, and all kinds of self-propelled armored mounts.

Lately, the design and procurement of vehicles used to transport supplies have been added to the responsibility of the Ordnance Department. It must be obvious from this that no supply service has faced or is facing a procurement problem comparable in its magnitude and complexity to that confronting the Ordnance Department. Ordnance must obtain complete fighting equipment that has not been commercially produced in the ordinary course of manufacture as well as equipment and parts thereof for the United Nations. The conditions of national emergency and of war multiply manyfold the demands for weapons and other military items over peacetime requirements and production. New plants must be built, new machine tools must be made and installed, labor must be trained, and new assembly procedures designed. The Ordnance Department is responsible for the design and development of new weapons, tests them, and when finally found acceptable, procures them for the using service and supplies them to the troops in the field. In simple language, the Ordnance Department is the mechanical-engineering design, manufacturing, and maintenance depart ment of the Army.

PRODUCTION IS RESPONSIBILITY OF INDUSTRY

The Army Ordnance program today approximates $50,000,000,000. When it is realized that for twenty years following the close of the last war the average annual appropriation for Army Ordnance was $12,000,000, some concept is given of the tremendous load industry is bearing in the ordnance effort. The entire production of ordnance, outside of the six old-established manufacturing arsenals, is the responsibility of industry, and this responsibility is being discharged in typical American fashion. A few examples of the radical conversions required, I believe, will suffice to portray this to you. Toy manufacturers have produced canister; a former bedding company has made links for machine-gun belts; printing-press manufacturers have turned to guns and shells, and so on. A complete new explosives industry for smokeless powder, TNT, rifle and cannon ammunition, and the like, was constructed at a cost of three and a half billion dollars.

In addition to changing finished products to meet changing conditions of modern war, it was necessary to adopt new methods of manufacturing to avoid shortages of precious machine tools, and frequently it was necessary to redesign the product itself to conserve rubber, copper, aluminum, and the valuable alloying elements in which critical shortages developed when the vast demands of war were felt.

I could spend a great deal of time giving you examples of the savings which resulted from the adoption of new methods of manufacture and redesigning products. A typical example, however, will suffice. One item formerly made of precious aluminum is now made of steel on mass-production presses. On one order for 1,500,000 of these items enough aluminum to make 550 bombers and 600,000 machine-hours will be saved.

Committees have been organized among the industries engaged in the manufacture of the same ordnance item with resultant reductions in cost, savings in valuable machine-tool time, and elimination of bottlenecks. The committees meet to interchange information regarding production techniques and processes and to consider and make recommendations with respect to problems of production and the supplying of materials and components.

Today, after two and one half years of intensive effort, the flow of the production of ordnance matériel compares favorably with that of our enemies who were preparing for this war over a period of many years. This is a result of which American industry may well be proud.

CONDITIONS OF WAR MAKE CHANGES INEVITABLE

If Major General Levin H. Campbell, Jr., Chief of Ordnance, were here today, I know he would want to proclaim to the fathers and mothers of these graduates his deep sense of personal responsibility to see that the men who fight have the best weapons human skill can provide. He has selected the best and most experienced men to give continuing attention to this. Laboratories all over the country have been called into service for development and research on new weapons. Proving grounds have been established and are continually testing ordnance matériel under normal as well as desert and arctic conditions. Missions are at battle points to observe the performance of our own and enemy weapons, all to the end that our troops will have the best of weapons. This is a continuing process, for although the words of our generals at the front today testify to the fine quality of our weapons, the Ordnance Department realizes that even in a short war the best today may be worthless or obsolete tomorrow.

The shifting emphasis of war necessitates changes in the production program and forces the limited quantity of war materials into different channels. Cargo vessels and aircraft at the moment may need materials used by Ordnance with consequent shifting in the manufacturing plants. The shifts obviously throw a tremendous burden on the skill and the experience of industry. Ordnance, while large, is but one of many programs that must be bent to the exigencies of the moment.

The success thus far obtained in war production, in training and transportation of our troops to the firing line, their bearing in battle, and the faith in our united effort give confidence that we will proceed through this part of our adventure of tomorrow to ultimate success, however near or remote that goal may be.

AFTER THE WAR, WHAT?

Some successes obtained in battle have already prompted the question, "After the war, what?" It is too early to ask the question and much too early to answer it. The question seems to imply a parallel to 1918 when the Armistice brought an abrupt cessation of hostilities and a sudden shock to our economy which was not entirely absorbed when we entered the current war. Should not our considerations lean more to the possibilities of a more gradual reduction in combat, one enemy prone while the other carries on, and the desirability of continuing military effort during peacetime as an important requisite of retaining the security and freedom we hold dear? In this connection a quotation from an address by James Garfield near the close of the Civil War stands out vividly, "This nation is too great to look for mere revenge. But for the security of the future I would do everything."

Regardless of when peace comes, there are some things now apparent that will have a real bearing on the lives of everyone in this room. Two of these bear particular mention.

The first is the tremendous program of wartime research in materials which will provide new products and new uses for old products. This should result in demands for goods and

services that may cushion the shock from a war to a peace economy and provide jobs that are necessary to bring our newly restored security to a working basis.

The second is the enlarged part that government has played in the daily life of the individual during the war period. Barring a ballot-box revolution of "return to normalcy" like that of 1920, this governmental influence will continue. It is significant that Elihu Root in his lectures in a Yale series on the citizen's part in government, published in 1920, pointed out that "the crowding and complications, the inventions and improvements, and co-operation of modern life have enormously increased the dependence of men on each other," and "the proportional part played by government in the personal affairs of every individual life is rapidly increasing." Mr. Root's statement will have much greater weight as the conflict wanes. This gives place for Mr. Root's further words, "The hope for the permanence of modern civilization is that it is being built up from the bottom through the participation of the whole people in that universal combined action for the common good which we call popular government."

I have shown rather sketchily some of the problems which confront our nation at the moment and in the near future in the hope that your minds and hearts will accept the challenge. This is an exciting time to be leaving your Alma Mater. You have had a good formal education and your services are in demand. You have unbounded opportunity to give mightily in this struggle for security which will not be over when the combat ceases. I need not remind you that the struggle will be fraught with challenging problems.

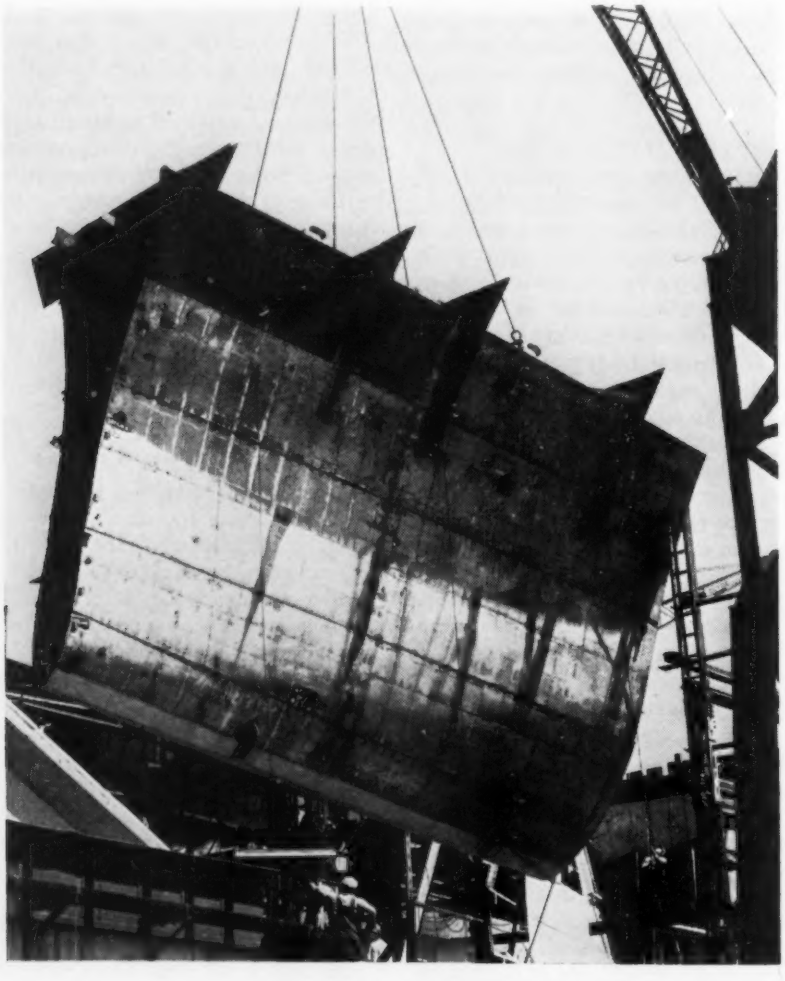
If you take away only two ideas of my talk, let them be these:

In addition to your character and trustworthiness, your success will be largely in proportion to your capacity to grow. While your formal training is in part over, your education is now beginning. From now you set your own tasks of instruction. Set them well with high goals and strive to attain them. Some of you are going into the armed forces, some into industry. In your new environment you will have ample opportunity to display your capacity to learn and grow.

The second is a further quotation from Elihu Root:

"The scheme of popular government upon which so much depends cannot be worked successfully unless the great body of such men (and women) as are in this room do their share; and no one of us can fail to do his share without forfeiting something of his title to self-respect."

The adventure of tomorrow is a complex enterprise. The war is to be won. The nation's industries, now all-out on war production, must be converted to peacetime products in a way to insure that men will be employed. Wise national policies must be developed by the well-tested democratic process to insure a security of mind in our nation and in other nations. You who have the advantages of a good education have a grave responsibility to exert leadership so that the problems brought about by unforeseen events will be resolved and the continuing adventure of tomorrow will be a success.



BUILDING TODAY'S SHIPS

(Forty-foot "slice" of destroyer is swung into place. See also page 136 of this issue.)

The PRIDE *of* AMERICA

By A. A. POTTER

DEAN OF ENGINEERING, PURDUE UNIVERSITY, EXECUTIVE DIRECTOR, NATIONAL PATENT PLANNING COMMISSION

THE industrial progress of this country and the high standards of living of our people have usually been attributed to the abundance of our natural resources. Few, however, realize that the Americans, to a greater degree than any other people in the world, are responsible for most of the epoch-making inventions of the past century. Has any person in any other country given as great an impetus to mechanized agriculture as did Cyrus Hall McCormick in 1833, when he invented the reaper? Have any contributions equaled the pioneer inventions in the field of communication which were made by four Americans, Samuel F. B. Morse (first practical telegraph, 1832), Cyrus W. Field (first transatlantic cable, 1858), Thomas A. Edison (first quadruplex telegraph, 1874) and Alexander Graham Bell (first practical telephone, 1876)? In radio the names of Fessenden, Lee de Forest, Alexanderson, Armstrong, and Jenkins are a credit to our land. From the invention of the *Clermont* of Fulton, in 1811, to the patent for the airplane by Wright in 1903, Americans have been major contributors to the field of transportation. Among these are Vail (the electric locomotive, 1851), Westinghouse (the air brake, 1869), Sprague (the trolley car, 1882), Duryea and Haynes (the first practical automobiles, 1885), and Sperry (the gyrocompass, 1905). Among American inventions are also included many new manufacturing processes, such as vulcanizing rubber, cracking gasoline, welding, and the manufacture of calcium carbide, aluminum, and plastics. The sewing machine, typewriter, talking machine, camera for films and plates, adding machine, and many other devices which contribute to human comfort and effectiveness are also the creations of American men of genius. The accompanying table lists 75 U.S.A. inventions between 1793 and 1930, an incomplete picture but indicative of the contributions of American inventive genius during the past century.

Many of the great inventions by Americans were made by people between the ages of 21 and 40. Westinghouse invented the air brake when he was only 21, McCormick the harvester at the age of 22, Howe the sewing machine at 27, Colt the revolver at 28, Eli Whitney the cotton gin at 29, and Wilbur Wright the airplane at the age of 36. These youthful inventors of our young country and many others like them, whose creative genius has been responsible for converting our natural resources into great industries, are the true "pride of America."

INVENTIONS EXTEND GAINFUL EMPLOYMENT

Economic security for the people of this country was achieved in a large measure by inventions which have definitely extended gainful employment. Only one in six inventions has as its primary purpose the saving of labor; the other five sixths of all inventions create employment, increase wages, increase wealth, decrease drudgery, improve working conditions, improve quality of product, and reduce the cost of goods. Even in 1940 fourteen million persons in this country were earning their livings in the manufacture, sale, and distribution of patented goods, and this number is much greater at present.

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

This country has attracted and developed the most inventive talent in the world, because our Government has always placed the rights of the individual above those of the state. Dr. John A. Dienner, a prominent engineer and patent attorney of Chicago, stated, "The American Revolution and the Constitution to which it gave rise emphasized or idealized the rights of the individual. The Constitution and the laws which followed it clothed the inventor with more than mere property rights—the inventor is treated as a special individual of an exalted character, instead of a normal individual doing the work that is expected of him. . . . The American patent system emphasizes the rights of the individual and hence is consistent with the theory of government under which we have attained our greatness. No other country in the world offers to inventors the incentive and opportunity which is furnished by the American patent system."

AMERICAN PATENT SYSTEM ENCOURAGES INVENTION

The groundwork for the American patent system, a most vital factor in the industrial progress of this country, was laid in Philadelphia in 1787, where the Constitutional Convention gave Congress (Article 1, Section 8, Constitution of the United States) the power "to promote the progress of science and useful arts by securing for a limited time to authors and inventors the exclusive right to their respective writings and inventions." The bill which created our patent system was signed on April 10, 1790, by George Washington. More than half a century after the creation of our patent system President Abraham Lincoln said, "The Patent System added the fuel of interest to the fire of genius." Our patent system has been at all times one of the outstanding pillars of American democracy and a stimulus to individual enterprise.

Our patent system, which encourages and rewards creative talent, has been a major factor in changing, in a brief period of only 152 years, a small struggling nation into the most powerful industrial power in the entire world, where people enjoy the greatest freedom and the highest level of living known in history. More than five million persons are working in this country in industries which have been made possible by the protection afforded by our patent system. Has the American public paid too great a price for yielding to the inventor the exclusive right to his creation for a period of only seventeen years? Would the telephone, the radio, or the plastics industry have been commercialized for the benefit of the public without patent protection?

The American patent system grants to the inventor certain "exclusive rights" in return for his full disclosure to the public of his invention and for creating something which is new. The law of patents implies the right of the inventor to keep his discovery secret and offers him a reward for disclosing it. In return for temporary security, the inventor discloses his invention, which becomes part of the public domain upon the expiration of 17 years. The patent is a reward for the creation of something new, for an addition to and not a subtraction from the public wealth. Disclosure through the patent stimulates others in their creative endeavors. A patent represents the creation of something new, which the public has not had before, and the widespread sharing of the benefits of invention is made possible by our patent system. Any radical changes in our patent

LIST OF 75 MAJOR U. S. A. INVENTIONS 1793–1930

	Invention	Date	Name of Inventor
1	Cotton gin	1793	Eli Whitney
2	Steamboat	1811	Fulton
3	Telegraph	1832	Morse
4	Reaper	1833	McCormick
5	Process vulcanizing of rubber	1839	Goodyear
6	Babbitt metal	1839	Babbitt
7	Sewing machine	1846	Howe
8	Improved water wheel	1847	Francis
9	Corliss engine	1849	Corliss
10	Magazine gun	1849	Hunt
11	Electric locomotive	1851	Vail
12	Power elevator	1852	Otis
13	Sleeping car	1856	Woodruff
14	Cable car	1858	Gardner
15	Machine gun	1862	Gatling
16	Compressed-air drill	1866	Berleigh
17	Automatic gear cutter	1867	Sellers
18	Typewriter	1867	Sholes
19	Chilled plow	1868	Oliver
20	Air brake	1869	Westinghouse
21	Celluloid	1870	Hyatt
22	Railway block signal	1872	Robinson
23	Automatic car coupler	1873	Janney
24	Barbed-wire machine	1874	Glidden
25	Quadruplex telegraph	1874	Edison
26	Submarine	1875	Holland*
27	Water gas	1875	Lowe
28	Automatic binding for harvesters	1875	Appleby
29	Mowing machine	1876	Eikenmeyer
30	Telephone	1876	Bell
31	Electric welding	1877	Thomson
32	Talking machine	1878	Edison
33	Electric arc lighting, commercial system	1879	Brush
34	Incandescent lamp	1880	Edison
35	Camera for plates	1881	Schmidt
36	Trolley car	1882	Sprague
37	Cash register	1883	Ritty
38	Fountain pen	1884	Waterman
39	Linotype	1885	Mergenthaler
40	Practical automobile	1885	Duryea and Haynes
41	Practical distribution system for a-c power	1886	Westinghouse
42	Electric-resistance welding	1886	Thomson
43	Rotary converter	1887	Bradley
44	Polyphase electric systems	1887	Tesla
45	Monotype	1887	Lanston
46	Adding machine	1888	Burroughs
47	Transparent photograph film	1888	Eastman
48	Combine (harvester and thresher)	1888	Matteson
49	Aluminum (extraction process)	1889	Hall
50	Carborundum	1891	Acheson
51	Automatic dial switching for telephone	1892	Strowger
52	Color photography	1892	Ives
53	Motion-picture machine	1893	Edison
54	Zipper	1893	Judson
55	Multiple system train control	1895	Sprague
56	Modern disk plow	1896	Hardy
57	Loading coil—making long-distance telephony possible	1900	Pupin
58	High-speed steel	1901	Taylor and White
59	Mercury converter	1903	Hewitt
60	Caterpillar tractor	1900	Holt
61	Airplane	1903	Wright Brothers
62	Automobile starter	1903	Coleman
63	Safety razor	1904	Gillette
64	Glass-shaping machine	1904	Owens
65	Gyro-compass	1905	Sperry
66	Thermionic tube (triode)	1906	de Forest
67	Bakelite	1909	Baekeland
68	Hydroplane	1911	Curtiss
69	Mercury vapor arc	1912	Peter Cooper Hewitt
70	Ductile tungsten filament for incandescent lamps	1913	Coolidge
71	Cracking process for gasoline	1913	Burton
72	Gas-filled incandescent lamp	1916	Langmuir
73	Airplane compass	1917	Mendenhall and Williamson
74	Inconoscope ("all-electric" scanning tube for telecasting)	1923	Zworykin
75	Kinescope ("all-electric" receiving tube for television)	1930 (about)	Zworykin

* Modern submarine invented by Holland in 1902

system would stifle technical progress through secrecy and would prove detrimental to the public.

Patent protection is essential to general welfare, as well as to industrial progress. Without full protection afforded the inventor for a limited time, he would keep his discovery a secret. This knowledge would die with him, and society would lose a valuable social heritage.

Our patent system has provided the protection necessary to attract the capital needed to develop new types of production. Invention is essential for industrial progress, but industry will not spend money on research or for the purchase of inventions unless such new knowledge as it acquires can be protected by patents.

Our patent system has provided the incentive to capital to encourage research and to commercialize invention. Inventiveness and socialization of industry do not mix. It is useless to invent unless capital can be attracted to commercialize the invention. Stimulating invention involves encouragement to capital and management to develop new devices and new products. The patent system provides an effective stimulus to inventors and adequate protection to the management and capital which have backed creative genius. In striving to improve the patent system, let us not change it to such an extent that capital would not be available for developing new ideas. Let us remember that the ownership of patents and the control it gives over the inventions covered are the very lifeblood of many industries which would not have existed without patent protection.

A GOOD PATENT SYSTEM ESSENTIAL FOR FUTURE PROGRESS

The need for a good patent system is greater today than ever before, if maximum use is to be made of inventive talent in connection with our war effort and if we are to meet the challenge which will be ours to utilize most effectively our expanded industrial facilities when the war is over.

A good patent system must be coupled with other means of discovering and encouraging inventiveness in our young Americans. To kindle a spark of interest in creative endeavor on the part of our young people, they must be brought into contact with teachers who are themselves constantly striving to improve things, who are looking for the one best way, and who have a keen interest in eliminating waste. This means that our teachers, not only in our colleges and universities, but also in our elementary and secondary schools, must have a lively interest in creative endeavor.

We must also do everything in our power to increase recognition and reward for inventors. Our inventors are the true pride of America. They are entitled to every possible encouragement, opportunity, and reward, as their creative talent is our greatest asset in mechanized warfare, as well as in making postwar adjustments for a more abundant and better living in a world at peace.

FACTS *About the* RENEGOTIATION *of* WAR CONTRACTS

By ALBERT J. BROWNING

COLONEL, GENERAL STAFF CORPS

ENGINEERS are closely concerned with the production of war material and with the prices which the Government pays for such material. Almost all engineers take some part, and often an extremely important part, in influencing costs and hence prices. A large proportion of the enormous savings in manufacturing costs which have been realized are by improved methods of producing various types of war goods. These economies can be credited largely to the ingenuity of this country's engineers.

By the same sign the advances made by American engineers are also responsible for the creation of profits which in many instances exceed those that any patriotic contractor would desire. Engineers, therefore, are interested in how such profits shall be controlled in the best interests of the nation. The method chosen by the Congress to accomplish this is that of renegotiation.

In applying the already established principle of renegotiation to war contracts, the Congress was not in any way displaying distrust of war contractors. Everyone knows that American industrialists are good citizens and that about 99 per cent of them are in complete agreement with the principle that no one should be allowed unjustified, excessive, or inordinate profits from this war.

However, manufacturing conditions, because of the great variety of entirely new products required, are different now from in peacetime. The result has been, in many instances, to produce profits which might be called "unexpected" rather than excessive, but which by any name were larger than any good citizen would care to make from the war.

Since it is obvious that industry as a whole could not very well determine its own position, nor adjust its contracts in ways that would be fair to all, it became necessary to establish a means for meeting this situation, and the method that the Congress has provided is that which is established by the Renegotiation Act and its amendments.

TAXES WILL NOT DO THE JOB

It has been suggested that this procedure was unnecessary on the ground that excess-profits taxes would recover virtually every dollar in inordinate profits which a contractor might make. This view, however, is not a sound one. There are a number of matters involved which no tax formulas can handle. First is the fact that control of costs is just as important in the war program as the control of profits. Excessive profits may lead to excessive costs because they frequently fail to encourage cost control. Excessive costs in addition to the sheer waste of money which results from them lead inevitably to waste of materials and manpower, both of which are becoming increasingly scarce.

No form of excess-profits tax can have a constructive influence on this situation because such taxes do not encourage efficiency, since they do not reward it. The only practical way to meet this situation is through careful price control. When current prices are kept close to cost, the producer must exercise careful management and ingenuity to earn the reasonable profit.

In normal times the function of stimulating good management is performed by competition among producers. In war-time, since maximum production facilities must be utilized, and competition is not wholly operative, other means must be used to keep price close to cost and costs themselves down.

Another disadvantage of attempting this end by taxes is that taxes get the money too late. The money recovered through taxation has gone into circulation unnecessarily. It has added its influence to the inflationary spiral. In addition, it has injured the good name of the American system of free enterprise by giving the impression that war contractors are making excessive profits. The fact that these profits will be largely paid out in taxes does not clear the name of industry in the minds of the public.

Renegotiation of contracts, with elimination of unreasonable profits, reduces the number of dollars to be used to win the war and protects the good name of business from charges of profiteering.

The protection of free enterprise is of great importance, for this American principle is in real jeopardy. The charges of profiteering which created such long drawn-out scandals during the last war should not be repeated after this war. If they are, there will certainly be retaliation that will cause business setbacks of a most serious nature. Renegotiation of contracts, with the resultant avoidance of inordinate profits, provides protection from such threats to the system which has made America great.

Another aspect of the matter is the position of industry in relation to the postwar period. To win this war industry must be tough, strong, and efficient but to continue to exist it must also be in fighting trim in the future when it returns to a normal basis of operation. The rigid limitation of profit and the rewarding of extra efficiency—the policy of the Price Adjustment Board—builds the strength of industry both as to winning the war and winning the peace.

REWARDS FOR GOOD PERFORMANCE

Renegotiation has a further advantage because it considers many factors relevant to fair profits which are disregarded by taxation formulas, however carefully planned and administered. For example, it is the policy in renegotiating war contracts to consider the record of the contractor in the use of raw materials and manpower and as an efficient and expeditious producer of goods. If his performance is superior, it is the Board's view that he is entitled to a higher profit than another producer making the same matériel, but at higher cost, with slower output, or less efficient in other ways. No taxation formula could function on this basis.

Similarly, contractors who share their patent and other rights, who make important inventive contributions to the war effort, or in other ways make themselves particularly useful to the job, can count on making a larger profit than the run-of-mine, or below-average, producer. Here again are conditions that could not be handled by any possible taxation formula.

OTHER EVIDENCE OF EFFICIENCY WILL BE CONSIDERED

The Board also urges all contractors who may be subject to renegotiation proceedings to present at the first meeting a statement covering all relevant information not disclosed in financial statements. This should be a concise but complete statement of the company's contributions to the war effort. Speed in changing over from civilian production, improvements of methods and product, early attainment of quotas, or better, are examples of information which the Board will consider in its over-all examination of the contractor's profits position.

NOT PERFECT, BUT THE BEST DEVELOPED TO DATE

No one asserts that the renegotiation procedure is ideal, but it is definitely the best one so far proposed to attain the essential objectives in the field of war contracts. Properly administered, it does provide for current control of prices and for indirectly keeping costs down through pressure on price.

CREDIT ATTACHES TO RENEGOTIATED CONTRACTORS

It is particularly important to bear in mind that a willingness to discuss the matter of fair profits and prices and to work for a meeting of minds on profits under consideration is definitely to the credit of the contractor. It is evidence of a patriotic and public-minded spirit and is a legitimate subject for mention in the advertising or publicity of the contractor.

MEN WITH WHOM CONTRACTORS WILL NEGOTIATE

When contractors sit down with a renegotiator of the War Department Price Adjustment Board, they will find that they are meeting with a man who talks their own language. The personnel of the Board, and its staff, is drawn from men who have been identified with successful business enterprises for many years. These men understand the problems of business and are interested in reasonable and orderly negotiations. This is of prime importance in matters which call for good judgment to the degree that is essential in over-all contract renegotiation.

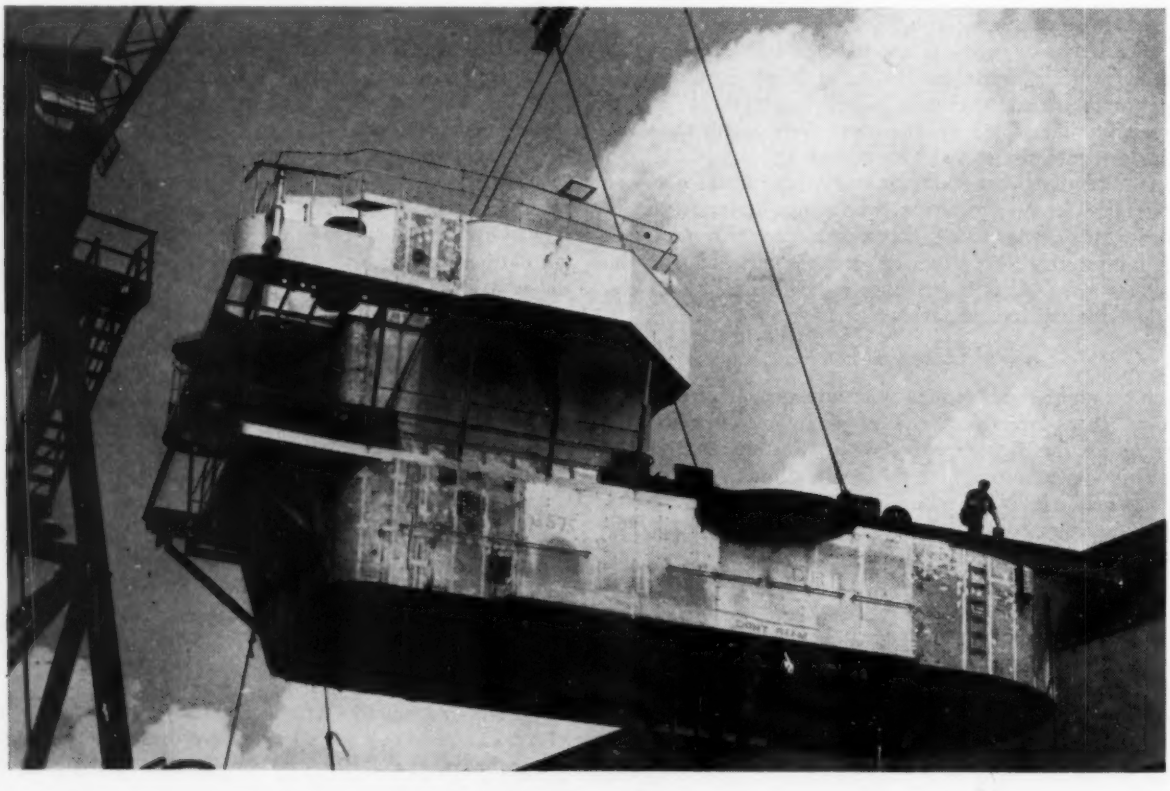
ADVANTAGES OF IMMEDIATE VOLUNTARY RENEGOTIATION

There are a number of reasons that make it good policy for a company handling war contracts to apply for immediate voluntary renegotiation. First of all, such negotiations are conducted on an over-all basis and are handled by a study of the contractor's over-all profit position and not the examination of the individual contracts.

When a clearance is based on estimated profit for the remainder of the year the right is reserved to look at the final realization. Should there be wide divergence from the original estimate the matter could be reopened but there would be no reopening for normal variations. Another important point is that if the contractor enjoys an increase in profit during the remainder of the period covered and can show that this profit has been due, not to the mere operation of mass production, but to his own extra effort, ingenuity, or invention, that profit may not be considered a basis for further renegotiation, and the contractor ordinarily will be allowed to retain some or all of it.

There is also, of course, the advantage which appeals to any sound management, namely, that an over-all renegotiation removes a contingent liability from the books and enables the contractor to make a clear and definite statement of his profit position.

The War Department Price Adjustment Board welcomes inquiries from war contractors and is prepared to discuss with them any details regarding their position in relation to such matters. Inquiries should be addressed to the Board, Room 3D 614, Pentagon Building, Arlington, Va., and will receive proper attention.



BUILDING TODAY'S SHIPS

(Prefabricated forward deckhouse of a destroyer swings into place as a unit. See also page 132 of this issue.)

INDUSTRIAL PSYCHOLOGY: INDUSTRIAL RELATIONS[1]

By IRVING KNICKERBOCKER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ONE of the most striking developments in the American industrial field during the last few years has been the rapid growth of interest in industrial relations. The growth of the union movement, which has served to point up the relations between management and labor, and the war, which has emphasized the necessity for the intelligent selection, training, placement, and handling of men, have led to an increased need for understanding the part played by human beings in industry. It appears highly probable that the student in a technological school in the future is going to have to add one more tool to his kit, no matter what his specialty. That tool should be an increased awareness of the problems involved in dealing with human beings.

Here at M.I.T., a group of us, in what is called the Industrial Relations Section, have set out both to explore that field and to discover methods for giving the student some understanding of it. Recently, there landed on my desk what seems to me to be a representative textbook in industrial psychology.[2] This book presents the practical applications that have been made by psychology in meeting the personnel problems of modern industry. It also serves to illustrate the ground covered by the standard course in industrial psychology as it is given in a good many universities in this country today. It should be interesting to examine the contribution of such a text to the general field of industrial relations, both from the point of view of what is there and of what is not there. The publisher's "blurb" states that the book "has covered the entire field thoroughly." From the point of view of *industrial psychology* as such, this is probably a fact. The book, however, most certainly does not cover the entire field of *industrial relations* or even approximate such a coverage. Academic psychologists have applied those tools which they have found ready in the field of psychology to those fields in industry where such an application appeared possible. The result has been a selective process within the entire field of industrial relations, not from the point of view of the importance of the problem to be dealt with, but merely from the point of view of the tested tools which were available.

It should be emphasized immediately that any influence brought to bear on the technological student which will serve to stress the importance to that student of the human being as a real and difficult problem in industry has served an important part in that student's education. There is no doubt that this text would do that job and do it rather well. Any criticism which may be made concerning the adequacy with which the text covers the entire field of industrial relations may be considered only as an added argument stressing still further the extent and importance of that field.

When the academic psychologist approaches the field of industry, he does so with a certain rigid training and background. On the basis of this background and training, he selects from the field as a whole certain problems with which he feels he can deal satisfactorily. In addition to these problems management itself has recognized certain others for which it has asked a solution. The textbook in industrial psychology, therefore, tends to be made up of the problems which the academic psychologist has selected and the further ones which have been dumped in his lap by the industrialist.

Psychology has long been interested in individual differences. Out of this interest has grown the field of testing. More than a third of the textbook deals with the value of the concept of individual differences as applied to industry. It brings out many commonly unrecognized differences in human beings and the importance of an awareness of those differences to the industrialist in his selection and placement of men. For years psychology has been working on the problem of isolating ways in which people may differ one from another, and of producing methods of measuring these differences, and of testing the significance of the differences and the validity of the measurement. Out of this work have come numerous tests of various kinds. Today there are still too many men in management who are either overly impressed by, or unnecessarily critical of, the psychologist and his tests. The very idea of testing human beings seems to arouse an emotional reaction in most people.

There is undoubtedly great value for the technological student in a study of tests. When he knows the bases on which they are constructed, the methods used in constructing them, how the tests are tested, he will know what they mean, how to evaluate them, and finally how to use them. The book contains a good discussion of the general principles of employee testing. The standard tests of mental ability, mechanical comprehension, dexterity, manipulation, and achievement are discussed.

It may be noted that of the many ways in which people differ, the tests just mentioned deal with only a small number, of relatively minor importance. A chapter in the text of only seven pages discusses what is called personality and interest. These seven pages are not a measure of the relative importance of personality and interest in the industrial field, but only a measure of the fact that there appears to be but one test having to do with personality which is utilized in the industrial field and one representative questionnaire on interest.

Psychologists have studied learning both theoretically and practically. They have something to contribute toward the practical problems of training in industry. The text presents something of the background of the field of learning, the application of this theory to problems within industry, and the results that may be anticipated from such application. There is no doubt that if a supervisor goes about the training process intelligently he will often be surprised at the results which may be obtained. So often in the past it has been expected that men would just somehow naturally learn a job and that the result would just naturally be satisfactory.

Psychologists have been interested for some time in the ability of one man to judge the personality characteristics of another. As a result they have knowledge and background

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Industrial Psychology," by Joseph Tiffin, Prentice-Hall, Inc., New York, N. Y., 1942.

which are valuable to that problem in industry which is now known as merit rating. The unsuspected pitfalls awaiting a man when he sets out to judge his fellow man and use his judgment for practical purposes are varied and bewildering. Obviously a reasonably accurate judgment of his men is one of the most valuable tools in the kit of the supervisor. The discussion of this subject in the text is well balanced for practical purposes. Out of 31 pages, 7 are devoted to a discussion of industrial merit rating and 24 are given over to a consideration of the dangers to be considered in using this tool.

Both the psychologist and the physiologist have been interested in some other problems in industry, partly because the industrialist has been interested also. Among these are such problems as work, industrial inspection, fatigue, visual problems, problems of accidents and safety. The combined efforts of psychologists and physiologists have produced some very worth-while results on each of these separate problems. Each is adequately covered and the material presented is of value to the student not only inherently but also for the emphasis it places on certain aspects of the problems which have not been recognized.

A final and brief chapter in the book is given over to what is called attitudes and morale. Here again the author indicates a field of vast importance but due to the absence of specific tools for dealing with the field, the chapter is short. Some tests and some questionnaires are discussed and their limitations revealed. It is quite apparent that the author realizes the size of the field by the many problems which he indicates as being there to be solved. Perhaps in this chapter more than any other the inadequacy of the approach from the point of view of what is called industrial psychology is most clearly revealed. The contrast between the few tools which have been developed and the tremendous import of the field is very great. It is only fair to point out that the author of this textbook seems well aware of the inadequacy of what he has to present. Over and over again he indicates problems at the same time that he criticizes the inadequacy of the tools, or the fewness of the tools which exist.

The examination of this textbook in industrial psychology has indicated the problems which the academic psychologist is well equipped to meet in the industrial field as a whole. The member of management with an interest in industrial relations will sit back and contemplate the field of industry as a whole with an awareness of all the problems to be found in it, and can scarcely be blamed for being mildly impatient with the industrial psychologist and his rather inadequate offering.

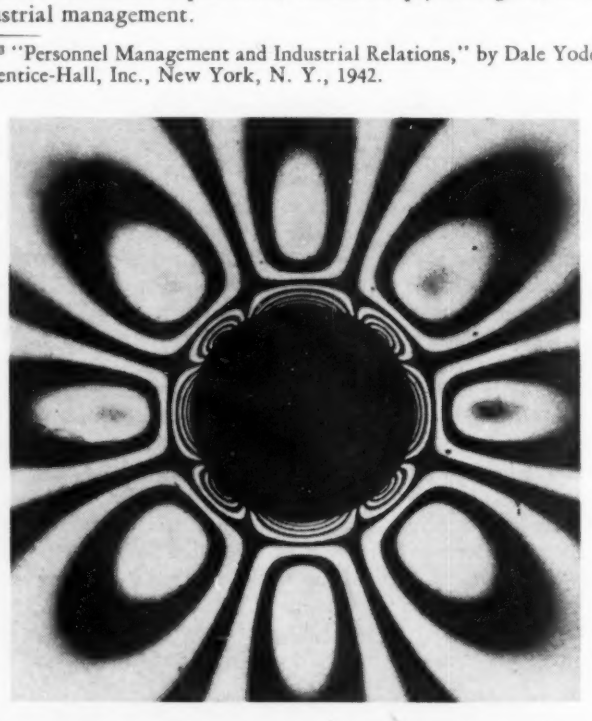
To students of industrial relations who have worked in the field, the setting within which the problems may be seen is about as follows: When the plant was small and the employer knew each employee personally, he did not need to be told that men were different one from another. He knew and made allowances for them just as he recognized similar differences among his children. The plant grew in size and somehow in the process managment lost sight of the human beings in the plant and set up in their stead a fiction. This fiction had to do with a mechanical man, a robot, a thing turned out by nature in an endless process of similitude. These "men" had little relation to human beings. Started by a whistle, kept going by dropping coins in a slot, and stopped again by a whistle, they formed the perfect adjunct to a world of machines and logically constructed production processes. Any confusion in this ideal theoretical picture was easily explained away on the basis of the division of "men" into good or bad. The process then was simply to get rid of the bad men and replace them with good men. In this time such simplicity of conception was sufficient for the practical necessity of industry.

Times have changed now and the pressures of unions backed by the government and the intense demands of wartime for production have necessitated a re-examination of the picture not for theoretical but for practical needs. The simple and machine-like ideal man has disappeared and in his place has appeared to management a bewildering, in comprehensible and perverse creature not unlike his own children. This human being never seems to do what he is expected to do. He is illogical, emotional, and in general a pain in the neck to management. The plant is once more full of human beings. Management deals now not with the ideal "man," but with an infinitely complicated pattern of balked ambition, unfulfilled desires, misplaced ills, troubles at home, bad children, and stern fathers, all the variegated factors which form the background of a real individual. The phrase "individual differences" seems rather a pallid one as an expression for such a rich and varied picture.

The student of industrial relations sees this as the field. The whole dynamic pattern of the interaction of human beings and the moving equilibrium of that pattern must be increasingly understood. That is the general problem. There are many specific problems, for example: How to institute a change which affects human beings, how to change the attitudes of human beings, how to achieve worker satisfaction, how to adjust the organization of management to the personalities involved so as to produce the most efficient setup, and how to achieve union-management co-operation.

A start has been made toward the solution of problems such as these. Published material is scarce and scattered. What is perhaps the first representative text has just appeared.[3] Students of the field are few, and more are to be found filling positions in industry than on the staffs of educational institutions. The demands of the field are for knowledge which has application whenever the organization of human beings toward some end is necessitated. The challenge implied is not limited to future supervisors, industrial psychologists, or industrial management.

[3] "Personnel Management and Industrial Relations," by Dale Yoder. Prentice-Hall, Inc., New York, N. Y., 1942.



A CIRCULAR DISCONTINUITY IN A FIELD OF PURE SHEAR (PHOTOELASTIC STRESS PATTERN)

(Photograph taken by W. M. Murray and shown at the Seventh Annual Photographic Exhibit held during the A.S.M.E. Annual Meeting, November 30–December 4, 1942, New York, N. Y.)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Torque Converters

TORQUE CONVERTERS. By P. M. Heldt. P. M. Heldt, Nyack, N. Y., 1942. Cloth, 5¼ × 8¼ in., 406 pp., 243 illus., $4.

REVIEWED BY E. S. AULT[1]

THE first reaction when reading "Torque Converters" was one of slight disappointment, unjustified perhaps but caused by the expectations aroused by the title. The author in his introduction immediately defines the term "torque converters" and limits his discussion to "transmissions for use with combustion engines in their various applications to the field of transportation." Included are elements not regularly associated with the term torque converters but which are frequently used with them, i.e., friction clutches, overrunning clutches. The inclusion of a discussion of gear-tooth forms and pitch selection was somewhat unexpected but is consistent with the treatment of the subject.

The title page states that transmissions described are mechanical, hydraulic, electric, pneumatic, differential; stepped and continuously variable; hand-controlled, automatic, and semiautomatic. The chapter headings give an indication of the treatment: friction clutches, automatic clutches, hydraulic couplings, overrunning clutches, some principles of toothed gearing, sliding-gear and constant-mesh transmissions, bearing loads in geared transmissions, planetary transmissions, electric drive, hydrostatic transmissions, hydrokinetic torque converters, differential or power-shunt transmissions, inertia-type transmissions, variable-throw transmissions, automatic and power-controlled stepped transmissions, pneumatic transmissions, geared transmissions for different services.

The treatment is largely one of abbreviated comment and description of numerous types tied together with slight historical reference. Many of the descriptions would be greatly clarified by one of the following: (*a*) two-plane projection figures, (*b*) simplified figures (to avoid obscuring operating principles by details of construction), (*c*) more detailed explanation. These defects are apparently the result of using figures selected from previous publications and will bother the novice much more than the automotive engineer.

The source of the various charts is not given so that one would hesitate to depend upon them for specific values. Their value is in making comparisons of application. The writer feels that the value of the text would be greatly enhanced had numerous specific references been given. Most of the descriptions are recognizable as having been secured from articles published originally in *Automotive Industries* and publications of the Society of Automotive Engineers and The Institution of Mechanical Engineers to which the author makes acknowledgment.

Although lacking in much of a theoretical nature, this book has considerable value to those who have occasion to investigate developments in transmission and the many engineers and otherwise, who are intrigued by the illusive variable-speed, positive-drive, automatic transmission with ample capacity that is simple and cheap to make and use. The writer is glad the book is available and recommends it to those who are interested in power transmission.

[1] Professor of Machine Design, Purdue University, West Lafayette, Ind. Mem. A.S.M.E.

Aircraft Design

REVIEWED BY JOHN E. YOUNGER[2]

INTRODUCTION TO AIRCRAFT DESIGN. By Thomas P. Faulconer, Director of Education, Consolidated Aircraft Corporation. Published by McGraw-Hill Book Company, Inc., New York, N. Y. Cloth, 6 × 9 in., 273 pages, numerous illustrations, $2.75.

THE primary purpose of this book is to bridge the gap between the field of aeronautical engineering and airplane design and other professional fields of engineering, architecture, and general design. The text gives engineers, draftsmen, and others a concise but complete view of the airplane as a design problem. The designers are thus aided in a better understanding of any particular phase of the design work and its relation to the complete design.

The text should also prove useful for use in professional courses in aircraft design as an introduction to the work, for example; about the junior year of an aeronautical-engineering course.

The text covers the following topics: Aerodynamics and preliminary design, power-plant installation, control surface design, wing structure, fixed equipment, hull design, breeching and landing-gear design, electrical equipment, aircraft hydraulics, structural design, modern aircraft materials, weight engineering, engineering contract administration, testing and research.

[2] Professor of Mechanical Engineering, University of Maryland, College Park, Md.; Secretary to A.S.M.E. Aviation Division. Mem A.S.M.E.

Books Received in Library

AIRCRAFT ENGINE MAINTENANCE. By J. H. Suddeth. John Wiley & Sons, Inc., New York, N. Y. Chapman & Hall, London, 1942. Cloth, 6 × 9½ in., 374 pp., illus., diagrams, charts, tables, $2.75. In addition to covering thoroughly proper methods of inspection, servicing, and repair, this work goes extensively into construction and operating principles, as a background for practical work. Engine components, fuels, fuel systems, carburetion, lubrication, ignition, instruments, accessories, and propellers are described in detail.

AIRPLANE STRUCTURAL ANALYSIS AND DESIGN. (Galcit Aeronautical Series.) By E. E. Sechler and L. G. Dunn. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1942. Cloth, 6 × 9 in., 412 pp., illus., diagrams, charts, tables, $4. The material in this book is divided into three major parts: Preliminary considerations in design; methods of structural analysis; and applied-stress analysis. The treatment of the standard structural problems has been held to a minimum. Emphasis is placed on the presentation of most of the recognized design criteria, with experimental evidence, when available, as to their exactness. Literature references accompany each chapter.

AMERICA'S FUTURE PATTERN. By E. S. Cornell, Jr., author and publisher, Larchmont, N. Y., 1942. Cardboard, 5 × 8 in., 214 pp., diagrams, charts, tables, $1.50. The author presents a picture of our present economic situation, explains what brought it about, and in-

dicates the correctives which he feels are necessary. Chapters upon politics, religion, education, and law are included as belonging to the complete picture.

BLUEPRINT READING FOR THE METAL TRADES. By W. A. De Vette and D. E. Kellogg. Bruce Publishing Co., Milwaukee, Wis., 1942. Cloth, $3\frac{1}{2} \times 11$ in., 132 pp., blueprints, diagrams, charts, tables, $2.50. Practical instructions are given for the interpretation of blueprints of machine parts. The text is illustrated by numerous actual blueprints for explanation or for practice work. The material is presented in such a way as to be of assistance to the mechanic who must make sketches himself, and a large group of miscellaneous problems and check sheets are included.

BOILER FEED AND BOILER WATER SOFTENING, a Boiler Operators' Manual. By H. K. Blanning and A. D. Rich. Third edition. Nickerson & Collins Co., Chicago, Ill., 1942. Cloth, $8\frac{1}{2} \times 11$ in., 164 pp., charts, tables, $3.50. Methods of testing water, the interpretation of tests, and the various treatments available for softening and purifying feedwater are discussed in detail in this book. The subject is discussed from the point of view of the operators of power plants, especially small ones of low and medium pressure, where expert chemical assistance is not readily available.

CHEMISTRY OF ENGINEERING MATERIALS. By R. B. Leighou, rewritten by the following members of the Chemistry Faculty of the Carnegie Institute of Technology: J. C. Warner (editor), T. R. Alexander, P. Fugassi, D. S. McKinney, H. Seltz, G. H. Stempel, Jr., and K. K. Stevens. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 645 pp., illus., diagrams, charts, tables, $4.50. The chemical properties of materials are discussed from the viewpoint of the user, to aid in their intelligent selection and use. This edition has been rewritten by a group of teachers and has been enlarged by new chapters on protective coatings, the shaping of metals, abrasives, glass and organic plastics, and alloys.

CODE OF MINIMUM REQUIREMENTS FOR INSTRUCTION OF WELDING OPERATORS. Part A Arc Welding of Steel $\frac{3}{16}$ to $\frac{3}{4}$ in. thick (tentative). American Welding Society, New York, N. Y., 1942. Paper, 6×9 in., 68 pp., illus., diagrams, charts, tables, $0.50. This publication is a revision of the "proposed" code issued by the American Welding Society in 1941, which was adopted by the War Production Board for use in defining an "accredited school." The revision has expanded the code considerably, especially the suggestions to persons organizing courses in metal arc welding. Requirements regarding school equipment, qualifications and duties of instructors, instruction in welding practice and theory, and final testing are given.

ENGINEERING QUESTIONS AND ANSWERS, Vol. 3. Emmott & Co., Ltd., London and Manchester, England, 1942. Cardboard, $7\frac{1}{2} \times 10$ in., 176 pp., illus., diagrams, charts, tables, 6s. These questions have been selected from those submitted by readers of the *Mechanical World* and *Engineering Record*, and are here republished with the answers prepared by the editors. A wide variety of practical shop problems is covered.

ENGINEERING MECHANICS. By F. L. Brown. Second edition. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 503 pp., diagrams, $4. A textbook in mechanics for students of engineering which is characterized by emphasis on methods of solution in which reference is made to relationships set forth verbally, as principles, rather than symbolically, as formulas. The new edition has many more problems than the first one, has new cuts, and has been completely reset.

ECONOMICS OF AMERICAN INDUSTRY. By E. B. Alderfer and H. E. Michl. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 566 pp., illus., diagrams, charts, maps, tables, $4. This is an introductory survey of the principal manufacturing industries of the United States, intended as a textbook for students of industrial management and industrial relations, and of economics. The predominant economic characteristics of the industries are set forth, and the basic character of each industry and its significant developments are interpreted.

FUNDAMENTALS OF INDUSTRIAL PSYCHOLOGY. (Industrial Series.) By A. Walton. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941. Cloth, $5 \times 7\frac{1}{2}$ in., 231 pp., diagrams, charts, tables, $2. This book has been prepared primarily for use as a text for foreman training in industrial plants. It states the essential concepts and principles of psychology and explains their application in industrial management. Topics discussed include aptitude and ability tests, psychological factors in production, fatigue problems, and morale.

Great Britain. Department of Scientific and Industrial Research. FUEL RESEARCH, Physical and Chemical Survey of the National Coal Resources No. 54. The Leicestershire and South Derbyshire Coalfield, South Derbyshire Area, the Eureka Seam. His Majesty's Stationery Office, London, 1942. Paper, $6 \times 9\frac{1}{2}$ in., 42 pp., illus., diagrams, tables (obtainable from British Library of Information, New York, N. Y., $0.90). This report, one of a series forming a survey of the coal seams of Great Britain, gives a comprehensive and detailed account of the physical and chemical properties of the coal of the Eureka seam in South Derbyshire.

Great Britain. Ministry of Labour and National Service. HOW FACTORY ACCIDENTS HAPPEN, Descriptions of Certain Industrial Accidents, Notified to H. M. Inspectors of Factories, Vol. 25, 1 November, 1941. His Majesty's Stationery Office, London, England, 1941. Paper, $6 \times 9\frac{1}{2}$ in., 33 pp., diagrams, (obtainable from British Library of Information, New York, N. Y., $0.15). The accidents described are classified in various groups: power and transmission, process machinery, lifting machinery, electrical plant, explosions and fires, gassing and poisoning, buildings and structural work, miscellaneous, and the worker. The types of accidents that are most common in wartime are given special attention.

GUN MANUFACTURE, compiled by the editors of *American Machinist*. McGraw-Hill Publishing Co., Inc., New York, N. Y., and London, England, 1942. Paper, $8\frac{1}{2} \times 11$ in., 138 pp., illus., diagrams, charts, tables, $1. The articles upon gun manufacture which have appeared in the *American Machinist* during the last two years have been collected in this convenient volume. Methods of tooling up for a variety of guns, as practiced in various American factories, are described in detail.

HANDBOOK OF APPLIED HYDRAULICS. By C. V. Davis. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Leather, 6×9 in., 1084 pp., illus., diagrams, charts, maps, tables, $7.50. A general reference work on hydraulics, composed of brief, yet complete texts on its various branches with practical information in the planning and design of hydraulic works. Hydrology, river regulation, dams, spillways, canals, hydroelectric plants, hydraulic machinery, water supplies, sewerage, irrigation, drainage, etc., are discussed by eighteen prominent engineers with experience in various fields.

HANDBOOK OF WAR PRODUCTION. By E. A. Boyan, with a foreword by E. H. Schell. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 368 pp., diagrams, charts, tables, $3. This handbook discusses the problems of management that are involved in the conversion of plants to the production of war materials and in increasing the quality and speed of output. It is based upon the experience of pioneer war manufacturers. Among the subjects discussed are the procurement of contracts, materials and supplies, production planning and control, quality control, labor and expansion, conservation of strategic material, industrial accounting in wartime, estimating for war contracts, and subcontracting.

HARDNESS AND HARDNESS MEASUREMENTS. By S. R. Williams. American Society for Metals, Cleveland, Ohio, 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 558 pp., illus., diagrams, charts, tables, $7.50. In writing this book the author has aimed to revive interest in an active study of the subject, to promote a more general outlook on the problem, and to bring together the literature on the subject in convenient form. The theories of hardness, the conditions underlying hardness measurements, and the various methods and instruments available are discussed. There is a bibliography of over 2000 references.

INDUSTRIAL MARKETING 1943 (Market Data Book Number, October 25, 1942). Published by Advertising Publications, Chicago, Ill., New York, N. Y., Los Angeles, Calif., San Francisco, Calif. Paper, 9×12 in., 415 pp., charts, tables, maps; not sold separately but included in annual subscription, $2, to the magazine, *Industrial Marketing*. The primary purpose of this annual is to supply advertisers with primary information on industrial markets and the publications that serve these markets. For each field, it presents the volume and kind of production, types and volume of materials purchased, geographical distribution of the industry, buying habits, and publications.

INTERNAL-COMBUSTION ENGINES. By J. A. Polson. Second edition. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, Ltd., London, England, 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 548 pp., illus., diagrams, charts, tables, $5. A textbook for junior or senior students of mechanical engineering "who have had a thorough course in fundamental thermodynamics and have a fair conception of the operation of internal-combustion engines." This edition has been completely rewritten and considerable new material added on cams, air cooling, and the performance of aircraft engines. A new chapter on gas turbines has been added.

INTRODUCTION TO ENGINEERING ECONOMY. By B. M. Woods and E. P. De Garmo. The Macmillan Co., Inc., New York, N. Y., 1942. Cloth, $6 \times 9\frac{1}{2}$ in., 441 pp., illus., diagrams, charts, tables, maps, $4. This textbook for engineering students is intended as an intro-

duction to the subject, in which the relation of such subjects as economics, accounting, and statistical methods to the economy of engineering enterprises is set forth.

LECTURES ON MACHINE DESIGN. By L. F. Moody. Princeton University Store, Princeton, N. J., 1942. Paper, 8½ × 11 in., 75 pp., diagrams, tables, $1.75. The lectures which have been combined in this volume are directed primarily to the application of the principles of the mechanics of materials to the more usual forms of machine members. These fundamental principles are extended in the various chapters to cover special cases and problems which are of importance in the design of machinery. Notes on practical applications are included.

MACHINERY'S HANDBOOK for Machine Shop and Drafting-Room. By E. Oberg and F. D. Jones. Eleventh edition. Industrial Press, New York, N. Y., 1942. Fabrikoid, 4½ × 7½ in., 1815 pp., diagrams, tables, $6. This popular reference book is too well known to need description. It presents a great store of practical information on machine design and shop practice, of the kind constantly wanted by mechanical engineers, draftsmen, and machinists. The new edition has been revised thoroughly.

MACHINE TOOLS AT WORK. By C. O. Herb. The Industrial Press, New York, N. Y.; Machinery Publishing Co., Ltd., Brighton, England, 1942. Fabrikoid, 6 × 9½ in., 552 pp., illus., diagrams, $4. Applications of modern machine tools of various types are illustrated by selected examples from actual practice. These examples are accompanied by close-up photographs and condensed descriptions, including the outstanding features of each job, with speed, feed, and other practical shop data. The emphasis i on the more unusual operations performed by modern machine tools, and a fair knowledge of shop practice is assumed.

MANUAL FOR AIRCRAFT HYDRAULICS, Theory, Maintenance, Design. By J. E. Thompson and R. B. Campbell. Aviation Press, San Francisco, Calif., 1942. Paper, 7½ × 10 in., 202 pp., illus., diagrams, charts, tables, $4. The design, operation, and maintenance of hydraulic systems and equipment as used in aircraft are presented in this text. Many typical units of hydraulic systems used by American manufacturers are described. The illustrations add to the text.

MARINE DIESEL HANDBOOK. By L. R. Ford. Diesel Publications, New York, N. Y., 1942. Fabrikoid, 6 × 9 in., 896 pp., illus., diagrams, charts, tables, $7 ($8, foreign countries). The machinery of a modern motorship is described and explained in this handbook, designed for those in charge of operation and maintenance. The principles of the Diesel engine, the types in use, and their construction are explained. Chapters deal with fuel, propulsion methods, Diesel-electric drives, supercharging, propellers, speed regulation, suppression of vibration and noise, electricity on the motorship, and accessory equipment.

MARINE ENGINEERING, Vol. 1, edited by H. L. Seward. Society of Naval Architects and Marine Engineers, New York, N. Y., 1942. Cloth, 8½ × 11 in., 353 pp., illus., diagrams, charts, tables, $6. This volume is the first of two which have been sponsored by the Society of Naval Architects and Marine Engineers as a companion to the "Principles of Naval Architecture" issued by it recently. Prepared by various authorities it is intended to provide a comprehensive treatise on up-to-date practice in merchant ships. Volume I deals with propelling machinery, power and revolutions, general design procedure, boilers, steam and Diesel engines, reduction gears, propellers and shafting, and materials and metallurgy.

MATERIALS TESTING AND HEAT-TREATING. (Rochester Technical Series.) By W. A. Clark and B. Plehn. Harper and Brothers, New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 132 pp., illus., diagrams, charts, tables, $1.75. This manual offers a series of laboratory exercises that suggest many commercial acceptance tests, but which have been adapted to ordinary school or college laboratory equipment. .The tests have been chosen for their educational value in illustrating fundamental principles as well as for their relation to commercial tests.

MATHEMATICS OF MODERN ENGINEERING, Vol. 2 (Mathematical Engineering). By E. G. Keller. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, 6 × 9½ in., 309 pp., illus., diagrams, charts, tables, $4. The three-volume work of which this is the second volume aims to present those aspects of mathematics which the experience of a large manufacturing organization, in dealing with mechanical and electrical investigations, has found to be of most value to engineers. This volume contains an explanation and elaboration of the fundamental method of mathematical engineering which includes the reduction of physical phenomena to a mathematical system and the solution of that system.

MECHANICAL PHYSICS. By H. Dingle. Ronald Press Co., New York, N. Y., 1942. Cloth, 5 × 8 in., 248 pp., diagrams, $2.25. The author divides physics into "mechanical" physics and "subatomic" physics and confines himself here to the first division—the properties of matter, heat, and vibrations and sound. The text is of college grade and aims to present physical principles in a manner that will bring out especially their applications in aeronautics and related subjects.

MERRIMAN'S STRENGTH OF MATERIALS, revised by E. K. Hankin. Eighth edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, 5½ × 9 in., 148 pp., illus., diagrams, charts, tables, $1.50. The new edition of this well-known textbook has undergone a thorough revision and rewriting. The reviser has designed it as a basic textbook for nontechnical students and mechanics, and has made it more practical than before.

MOTION AND TIME STUDY. (Rochester Technical Series.) By G. W. Chane. Harper & Brothers, New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 88 pp., diagrams, charts, $1.40. A simple discussion of methods of time and motion study, and their use in shop management is offered in this concise text. The book is intended as a guide to assist management personnel in increasing efficiency.

N.A.M. HANDBOOK ON WAR PRODUCTION, compiled and published by National Association of Manufacturers, Washington, D. C., New York, N. Y., San Francisco, Calif., August, 1942. Paper, 8½ × 11 in., 184 pp., charts, tables, $1. This handbook for manufacturers brings together the information needed by those having war contracts or seeking them. How to go after a contract, how to sell to the Government, and the principles of cost determination under Government contracts are explained. The organization and functions of the War Production Board are described in detail, and the functions of the various agencies set forth. The priorities regulations are given in full, and there is a list of priorities orders, and forms.

NATURAL TRIGONOMETRIC FUNCTIONS to Seven Decimal Places for Every Ten Seconds of Arc, together with Miscellaneous Tables. By H. C. Ives. Second edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, 7 × 10 in., 351 pp., diagrams, tables, $9. These tables give the natural sines, cosines, tangents, and cotangents. They also include eleven other tables frequently needed by surveyors. Errors in the previous edition have been corrected, and a table giving the tangents and cotangents to single seconds from 0 to 2 deg have been added. The tables are clearly printed and very readable.

NEW TECHNICAL AND COMMERCIAL DICTIONARY. Part 1, Spanish-English; Part 2, English-Spanish; Part 3, Conversion Tables of Weights, Measures, and Monetary Units. Compiled by A. P. Guerrero. Editorial Técnica Unida and Chemical Publishing Co., Brooklyn, N. Y., 1942. Fabricoid, 6 × 9½ in., 600 pp., tables, $10. This dictionary contains more than 50,000 words used in electrical, mechanical, chemical, and marine engineering, radio, mining, textile, and other industries. It includes modern words referring to mechanized and motorized warfare, aviation, meteorology, etc. There is also a separate section giving conversion tables of weights, measures, and monetary units.

PAPERMAKING ABSTRACTS, compiled by Tappi Committee on Abstracts and Bibliography, edited by R. G. Macdonald and V. F. Waters. Published by the Technical Association of the Pulp and Paper Industry, New York, N. Y., 1942. Paper, 9 × 11½ in., 270 pp., $2. This volume provides abstracts of articles and patents relating to the manufacture and technology of pulp, paper, paperboard, and paper products which have appeared during recent years. Special attention is given to foreign publications, which are abstracted very fully. Author and subject indexes are included.

PLASTICS FOR INDUSTRIAL USE, an Engineering Handbook of Materials and Methods. By J. Sasso. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 229 pp., illus., diagrams, charts, tables, $2.50. This manual discusses the plastics which are particularly suitable for industrial use. The comparative properties of the various types, methods of molding, the design of molds, and the machining and finishing of plastic parts are described. Separate chapters are devoted to specific plastics. A directory of trade names, suppliers, and molders is appended.

POISSON'S EXPONENTIAL BINOMIAL LIMIT: Table 1—Individual Terms; Table 2, Cumulated Terms. By E. C. Molina. D. Van Nostrand Co., Inc., New York, N. Y., 1942. Paper, 8 × 11 in., 47 pp., tables, $2.75. These tables give the numerical limiting values of the individual and cumulative terms for values of the parameter from 0.001 to 100. Originally prepared by the Bell Telephone System for use in solving switching and traffic problems, they are also very useful in handling inspection data and for solving problems of sampling.

POSTWAR PLANNING IN THE UNITED STATES. By G. B. Galloway. Twentieth Century Fund, New York, N. Y., 1942. Paper, 6 × 9 in., 158 pp., tables, $0.60. This report summarizes the activities, personnel, and publica-

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

tions of the various agencies engaged in research upon the economic and social problems that will face us when the war ends. A considerable bibliography is appended.

POWDER METALLURGY, edited by J. Wulff. American Society for Metals, Cleveland, Ohio, 1942. Cloth, 6 × 9½ in., 622 pp., illus., diagrams, charts, tables, $7.50. This volume contains 51 papers presented at conferences held in 1940 and 1941 at the Massachusetts Institute of Technology. Various problems connected with the preparation and use of metal powder are discussed by specialists, and a large amount of information is presented in convenient form. Most chapters have bibliographies.

PRACTICAL THERMODYNAMICS FOR AIRCRAFT ENGINES. By L. Thorpe. Aviation Press, San Francisco, Calif., 1941. Paper, 7½ × 10 in., 236 pp., diagrams, charts, tables, $3.50. The essentials of thermodynamics are here presented with the use of only simple arithmetic. The text is intended especially for mechanics of limited technical training who work with aircraft engines and have a knowledge of underlying principles.

PRINCIPLES OF EMPLOYMENT PSYCHOLOGY. By H. E. Burtt. Harper & Brothers, revised edition, New York, N. Y., and London, England, 1942. Cloth, 6 × 9 in., 568 pp., diagrams, charts, tables, $4.50, trade edition; $3.75, school edition. An interesting, readable presentation of the principles of psychology and of their application in the selection and training of business and industrial personnel. Mental and trade tests are described. The book can be used as a textbook or by businessmen for reference. The new edition has been completely rewritten.

PRINCIPLES OF HEAT ENGINEERING. By N. P. Bailey. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, 6 × 9½ in., 264 pp., diagrams, charts, tables, $2.75. The principles of heat engineering covered in this book may be considered as the minimum requirement for any engineer. The theoretical material presented is expressed quantitatively for use in the solution of engineering problems, of which a large group is included at the end of the text. The early chapters deal with general concepts, while the later ones cover respectively such engineering topics as internal-combustion and steam engines, turbines, boilers, and refrigeration.

PRINCIPLES OF IGNITION. By J. D. Morgan. Sir Isaac Pitman & Sons, London, England, 1942. Cloth, 5½ × 9 in., 133 pp., diagrams, charts, tables, 12s 6d. The purpose of this book is to describe simply and briefly the principal facts relating to the ignition of inflammable gas mixtures by sparks, flames, incandescent solid particles, and other localized sources. Certain theories which have been put forward to co-ordinate or explain the action of these sources are also described. The book is intended primarily for engineers concerned with internal-combustion engines and with the prevention of explosions in mines and factories.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. Seventh edition. Lincoln Electric Company, Cleveland, Ohio, 1942. Fabricoid, 6 × 9 in., 1267 pp., illus., diagrams, charts, tables, $1.50 in U. S. A.; $2 foreign. This well-known reference book offers a comprehensive, authoritative description of the arc-welding process. Methods and equipment, welding technique, procedures, speeds, costs, test methods, design of welded machines and structures, and typical applications of welding are considered. The new edition has been revised and enlarged.

Proceedings of the FIRST SOUTHERN CALIFORNIA MANAGEMENT CONFERENCE, "Manning and Managing Our Arsenal," held at California Institute of Technology, Pasadena, May 2, 1942. Paper, 9 × 11½ in., 49 pp., tables, $1. The papers here presented under the general theme of "Manning and Managing Our Arsenal" discuss such fundamental subjects as inventory and production control, the training of workers, and foremanship. In addition, attention is given to current problems of production, co-operative subcontracting, retooling for war work, and women in war industries.

READING ENGINEERING DRAWINGS. By G. F. Bush. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Linen, 9 × 11½ in., 60 pp., illus., diagrams, charts, blueprints, $2. This book has for its object the teaching of the reading of engineering drawings and of their reproductions in a clear, brief, and systematic manner. Only those basic ideas common to all branches of the subject are introduced, and the important branches of airplane drawing, machine drawing, and structural drawing are treated in detail. Actual working drawings are provided as examples.

REFRACTORIES. By F. H. Norton. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 798 pp., illus., diagrams, charts, tables, maps, $7.50. Since the publication of this treatise, ten years ago, much new information has accumulated, and has called for complete revision. To this edition there have also been added a chapter on fundamental concepts of matter in the solid state and five chapters on the selection and use of refractories in furnace construction in various industries. The work provides a good account of the fundamental processes involved in manufacturing and using refractories, and of the processes in current use in the United States.

SKILLED WORKERS FOR DEFENSE INDUSTRIES. By C. S. Slocombe. Personnel Research Federation, New York, N. Y. Paper, 9 × 12 in., 79 pp., charts, tables, $2. This pamphlet reports the results of a survey of the experience of various companies in obtaining skilled labor during boom periods. Methods of hiring, upgrading, and training are discussed, as well as such questions as the use of central placement offices, surveying anticipated requirements, estimating the employees capable of upgrading, selection of those to be trained, and the results of training. A wide variety of methods and results are described.

SIMPLIFIED DEFINITIONS AND NOMENCLATURE FOR AERONAUTICS, 1942, illustrated edition, a Modern Aeronautical Dictionary. By L. Thorpe. Aviation Press, San Francisco, Calif. Paper, 7 × 9½ in., no pagination, alphabetical arrangement, illus., diagrams, charts, tables, $2. This glossary of aeronautical terms contains about fifteen hundred definitions and explanations of words and phrases, accompanied by numerous drawings illustrating them. It is based on the nomenclature report of the National Advisory Committee for Aeronautics, supplemented by terms from other soucres.

SMOKE PREVENTION ASSOCIATION OF AMERICA, PROCEEDINGS, 36th Annual Convention, Hotel Statler, Cleveland, Ohio, June 2–5, 1942. Smoke Prevention Association of America, Chicago, Ill. Paper, 8½ × 11 in., 136 pp., illus., diagrams, maps, charts, tables, $1. The major part of this volume consists of the technical papers presented at the convention. The topics treated include atmospheric pollution, chimney performance, fuel conservation, and smoke-abatement practices. Several papers contain discussions of the relation of the subject to the war effort.

STEAM LOCOMOTIVE. By R. P. Johnson. Simmons-Boardman Publishing Corporation, New York, N. Y., 1942. Cloth, 6 × 9½ in., 502 pp., illus., diagrams, charts, tables, $3.50. In this book, the first on the locomotive to be published in many years, the chief engineer of the Baldwin Locomotive Works has set down certain fundamentals of locomotive theory and operation. In addition, attention is paid to the economics of the steam locomotive and to comparison with the Diesel-electric variety. The book contains much of interest to designers and those concerned with railroad motive power.

STONE THAT BURNS, the story of the American Sulphur Industry. By W. Haynes. D. Van Nostrand Co., Inc., New York, N. Y., 1942. Cloth, 5½ × 8½ in., 345 pp., illus., diagrams, maps, tables, $3.75. The story of the American sulphur industry is told at length, beginning with the first unsuccessful attempts to mine it in Louisiana. The growth of the industry following the successful introduction of the Frasch process is carried up to the present time, with some remarks on its future. The book is well documented and includes considerable statistical material.

STRATEGIC MATERIALS IN HEMISPHERE DEFENSE. By M. S. Hessel, W. J. Murphy, and F. A. Hessel, with a section on petroleum by H. J. Wasson. Hastings House, publishers, New York, N. Y., 1942. Cloth, 5½ × 8½ in., 235 pp., maps, charts, tables, $2.50. A timely popular account of the strategic and critical materials on the Army list. Their sources and potential sources are described, their uses are indicated and our needs are set forth, with some indication of the effects of shortages upon consumer goods, and of possible substitutes.

TABLE OF SINE AND COSINE INTEGRALS from 10 to 100, prepared by the Federal Works Agency, Work Projects Administration for the City of New York, conducted under the sponsorship of and for sale by the National Bureau of Standards, Washington, D. C., 1942. Cloth, 8 × 11 in., 185 pp., charts, tables, $2. This volume supplements the two previous volumes of "Sine, cosine, and exponential integrals" by providing sine and cosine integrals, calculated to ten decimal places, for the range of x, between 10 and 100, at intervals of 0.01. These integrals are encountered in many branches of physics andelectrical engineering,

and the volume is expected to meet the needs of workers in these fields.

TABLES OF PROBABILITY FUNCTIONS, volume 2, prepared by the Federal Works Agency, Work Projects Administration for the City of New York, conducted under the sponsorship of and for sale by the National Bureau of Standards, Washington, D. C., 1942. Cloth, 8 × 11 in., 344 pp., tables, $2. The two functions tabulated here are frequently called the ordinate and area, respectively, of the normal frequency curve, and are of fundamental importance in statistics, especially in testing the significance of a deviation in a normally distributed variate and in fitting normal distributions to observations. The tables extend to fifteen decimal places, at intervals of 0.0001 for x ranging from 0 to 1, and at intervals of 0.001 for x ranging from 1 to 7.8.

THEORY AND PRACTICE OF JOB RATING. By M. F. Stigers and E. G. Reed. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 5 × 8 in., 154 pp., charts, tables, $1.75. The method of job rating presented here claims to measure every element, including intangibles heretofore considered unmeasurable. The underlying philosophy is explained, a technique for actual evaluation is given, and questionnaires, rating scales, procedure for cross comparison, and full instructions are given.

THEORY OF FLIGHT AND AIRCRAFT ENGINES.—Air Pilot Training. By B. A. Shields. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 377 pp., illus., diagrams, charts, tables, $2.75. The present work is a revision and expansion of parts one and two of the author's "Air Pilot Training" and is designed to cover all the information on the theory of flight and on airplane engines called for by the examinations for certificates as a private or commercial pilot.

VANDERBILT RUBBER HANDBOOK, Eighth edition, 1942, edited by J. M. Ball. R. T. Vanderbilt Co., New York, N. Y., 1942. Cloth, 5½ × 8½ in., 464 pp., illus., diagrams, charts, tables, $5. This work brings together a large amount of technical information upon rubber, especially upon compounding for various purposes and upon testing methods. Dry rubber and latex are discussed.

Vultee Aircraft, Inc., Engineering and Development Dept. Report No. 260-28, ANALYSIS OF THE MESSERSCHMITT ME-110 AIRPLANE. Aero Publishers, Glendale, Calif., 1942. Paper, 8½ × 11 in., paged in sections, illus., diagrams, charts, tables, $2.50. In 1941 a German multiplace fighter in fine condition was obtained by Vultee Aircraft, Inc., and detailed studies and tests were made of its equipment and structure. The results of this investigation are analyzed at length in this report, which is accompanied by many drawings and photographs. The report should be of interest to aircraft manufacturers generally.

WAR GASES, Their Identification and Decontamination. By M. B. Jacobs. Interscience Publishers, New York, N. Y., 1942. Cloth, 6 × 9½ in., 180 pp., diagrams, tables, $3. The detection, sampling, and identification of chemical agents of warfare and the decontamination of areas and materials polluted by them are presented in this work. The book is designed to aid civilian officials in dealing with gas attacks.

WELDING. By J. A. Moyer. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9 in., 185 pp. illus., diagrams, charts, tables, $2.25. The major part of this textbook is devoted to oxy-acetylene and arc welding methods, especially applied to iron and steel. The apparatus and technique are described in a general way, with information on the metallurgy of welds, test methods and costs. A chapter on metal cutting is included, and other methods of welding (resistance, atomic-hydrogen, thermit) are described briefly. The text is clear and accurate.

YOUR CAREER IN TRANSPORTATION. By N. V. Carlisle. E. P. Dutton & Co., New York, N. Y., 1942. Cloth, 5½ × 8½ in., 188 pp., illus., tables, $2. Young men interested in vocational opportunities will find this book a sound guide to those available in the various transportation fields, rail, highway, water and air. The various positions are described, salaries are discussed, and requirements explained.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N.Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretation of this Committee formulated at the meeting of December 11, 1942, subsequently approved by the Council of the Society.

CASE No. 981 (Reopened)

(Special Ruling)

Inquiry: Is it permissible to use the following A.S.T.M. Emergency Alternate Provisions affecting existing Code specifications: EA-A27(S-11), EA-A83(S-17), EA-A135(S-58), EA-A178(S-32), EA-A192(S-40), EA-A194(S-51), EA-A209(S-48), EA-A213(S-52), EA-A216(S-56), EA-A217(S-57), EA-A240(S-62), EA-A249(S-64), EA-A250(S-65), EA-B62(S-46)?

Reply: It is the opinion of the Committee that the aforementioned A.S.T.M. Emergency Alternate Provisions in the corresponding Code specifications may be considered as meeting the intent of the Code.

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revision has been approved for publication as proposed addenda to the code. This is published below with the corresponding paragraph number to identify its locations in the various sections of the code and is submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. U-69(*a*). Revise to read:

(*a*) All vessels covered by this Code when constructed in accordance with the rules of this paragraph, and when the plate thickness of the shells and of the heads fabricated of more than one piece, do not exceed 1½ in. at the joint, may be used for any purpose and under any operating conditions with the following exceptions:

Par. U-69 vessels may not be used:

(1) To contain lethal substances, either gases or liquids;

[(2) To contain liquid at temperatures exceeding 300 F;]

(2) [3] For operating pressures exceeding 600 [400] lb per sq in.;

[(4) For operating temperatures in excess of 700 F.]

The limit of plate thickness does not apply to heads formed of a single plate. The pressure limitation does not apply to vessels operating under hydrostatic pressure at atmospheric temperatures.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Engineering Conference at New York, N. Y., January 7, Hears L. R. Boulware, W.P.B., on War Production in 1943

MORE than one thousand engineers of the metropolitan area gathered in the ballroom of the Pennsylvania Hotel in New York on the evening of January 7 at a War Production Conference to listen to an inspiring and informative address by L. R. Boulware, assistant to W. L. Batt, entitled "War Production in 1943." Mr. Batt, who is a past-president of The American Society of Mechanical Engineers and vice-chairman of the War Production Board, was to have addressed the dinner, but last-minute changes in his plans necessitated his presence in New Orleans instead of New York. Whatever disappointment his audience may have felt when they discovered Mr. Batt's absence was quickly forgotten once Mr. Boulware entered into the delivery of his address. It was generally conceded that Mr. Boulware had brought as important a message as Mr. Batt would have delivered and that the vigor of his personality had afforded abundant evidence of the quality of the W.P.B. staff. This introduction of Mr. Boulware to an audience of New York engineers will greatly strengthen their confidence in the Board and provoke increased interest in the special assignments that are being given to Mr. Boulware.

Panel Meetings Follow Dinner

The dinner, which was followed by seven panel meetings held concurrently in various parts of the hotel, was sponsored by The American Society of Mechanical Engineers, through its Metropolitan Section, and the following organizations: Society of Automotive Engineers, Army Ordnance Association, American Institute of Chemical Engineers, American Foundrymen's Association, American Institute of Electrical Engineers, American Society for Metals, American Society for Testing Materials, Society of American Military Engineers, American Society of Mining and Metallurgical Engineers, Society of Naval Architects and Marine Engineers, American Society of Tool Engineers, and American Welding Society.

The conference was called at the request of the War Production Board.

The toastmaster at the dinner was R. E. Gilmor, president, Sperry Gyroscope Company, Inc. Seated with Mr. Gilmor and Mr. Boulware at the head table were: J. J. Hogan, chairman, New York chapter, A.S.T.E.; George Schneider, acting chairman, New York section, A.W.S.; W. C. Mearns, chairman, New York chapter, A.S.M.; M. P. Davis, chairman, New York District Committee, A.S.T.M.; J. S. Vanick, chairman, War Problems Committee, Metropolitan chapter, A.S.T.M.; H. Happersberg, chairman, New York section, S.A.E.; S. Hogerton, chief deputy director, W.P.B.; Col. R. W. Johnson, district chief, New York Ordnance District; Harold V. Coes, president, A.S.M.E.; C. A. Hescheles, member A.S.M.E., chairman, War Production Conference Committee; H. L. Seward, council member, S.N.A.M.E.; G. J. Nicastro, chairman, Metropolitan Section, A.S.M.E.; F. B. Ely, secretary, New York section, A.I.M.E.; W. J. Murphy, chairman, New York section, A.I.Ch.E.; J. W. Queen, Jr., chairman, New Jersey chapter, A.S.M.; and H. W. Ryno, secretary, Northern New Jersey chapter, A.S.T.E.

After Mr. Boulware had delivered his address, the text of which will be found in this issue, Mr. Gilmor announced the location of the seven panel meetings which followed and introduced the chairman who presided over these sessions.

The purpose of these panel meetings was for the informal discussion of shop problems by plant foremen, superintendents, and engineers. As Mr. Batt said in his letter to the engineers in the New York City area which appeared with the announcement of the conference, total war "calls for the utmost ingenuity on the part of every American. It particularly demands that the results of the exercise of this ingenuity be freely exchanged in order that our country obtain the maximum production while practicing the ultimate economy in materials, in manpower, and in the use of materials."

Presiding at Sessions

At the panel on ordnance inspection, Col. Robert W. Johnson, chief, New York Ordnance District, presided, and Frank J. Oliver, technical editor, *Iron Age*, acted as secretary. The panel discussed methods, specification tolerances, and co-operation with ordnance inspectors.

See Page 149 of This Issue!

Your attention is particularly called to page 149 of this issue on which appears the names of all of the members of the A.S.M.E. Nominating Committee for 1943 with their addresses and the Group they represent.

Read the request of the Committee who urge you to suggest nominees for office in the A.S.M.E. in 1944. Suitable forms will be furnished by the Committee on request.

Sidney D. Kirkpatrick, of the Consultative Committee on Engineering Manpower, War Manpower Commission, and editor, *Chemical and Metallurgical Engineering*, conducted the panel on manpower problems, with H. C. R. Carlson, chief engineer, Lee Spring Company, Brooklyn, N. Y., as secretary.

Machine-shop problems were considered in a panel directed by George Richroath, superintendent, Lake Success Plant of the Sperry Gyroscope Company, Inc. William J. Hargest, associate editor, *American Machinist*, served as secretary.

The panel on chemical-plant equipment was led by Walter J. Murphy, editor, *Chemical Industries*, with Harry P. Outcault, St. Joseph Lead Company, New York, acting as secretary.

Metallurgical problems were discussed in a panel at which W. C. Mearns, International Nickel Company, New York, N. Y., acted as chairman and Fred P. Peters, Industrial Salvage Branch, W.P.B., and managing editor, *Metals and Alloys*, was secretary.

James S. Vanick, chairman, War Problems Committee, metropolitan chapter, American Foundrymen's Association, and K. A. De Longe, International Nickel Company, New York, N. Y., were chairman and secretary, respectively, of the panel on foundry problems.

Welding problems were considered at a panel over which H. R. Morrison, The Linde Air Products Company, New York, N. Y., presided, and George Schneider, Acetylene and Welding Equipment Company, Brooklyn, N. Y., acted as secretary.

The President's Page

How the A.S.M.E. Can Help Win the War

I KNOW you will bear with me as I present my messages to you from time to time through the medium of this page, as it is a physical impossibility for me to speak personally to all of you, much as I would like to do so.

There are many things the Society can do as an association of engineers to help win the war. There are many things that it has done and is now doing as you well know. I hope you will call the Council's attention to anything that in your judgment the Society can do and is not now doing in the war effort.

When the time comes and you are called upon to assist in any of these projects, as your experience and qualifications fit a given situation, I know you will do what you can to further the project and attain the objective.

In some situations small groups and even individuals are all that may be required to meet the situation. In other cases larger groups may have to be called on to cope adequately with the problem presented.

For example, many of you are engaged in assisting the War Production Board in conducting the War Production Conferences that are now being held in industrial centers all over the United States. These conferences afford our local sections an opportunity to be of service.

Another example is the contract which the Society has made with the Ordnance Department to supervise a research project in shell forging. Scores of industrial establishments and engineers are co-operating in this project under the well-tried procedure of A.S.M.E. Technical Committees.

I am sure you want your Society to utilize its facilities to serve the war interest to the best of its ability where it can do so effectively.

(*Signed*) H. V. COES, *President, A.S.M.E.*

A.S.M.E. 1943 Spring Meeting at Davenport, Iowa

Tri-Cities Section to Be Host

THE Spring Meeting of the A.S.M.E. to be held at Davenport, Iowa, April 26–28, 1943, with the Tri-Cities Local Section of the Society acting as host, takes on added importance in that it is the only meeting being held in the central part of the United States this year as there will be no Fall Meeting and the Semi-Annual Meeting will be held in Los Angeles in June.

The Tri-Cities Section includes Davenport, Rock Island, and Moline and abounds in plants manufacturing war materials in addition to the huge production plant at Rock Island Arsenal. The experience at all meetings of the A.S.M.E. since Pearl Harbor has been that attendance has been larger than it was at peacetime meetings. The programs of the Society are pointed entirely at the war effort and the results of meetings have been greatly to enhance production of war matériel.

Suggestions for Speakers or Subjects

All members of the Society are encouraged to submit suggestions for speakers or subjects that they recommend for consideration for the Spring Meeting program. These should be forthcoming promptly in order to be effective.

Davenport is in the center of an area which holds a large percentage of the Society membership and which also permits travel either by day coach or motorbus. Therefore it will not put any considerable burden on Pullman railroad transportation.

Divisions which have expressed an interest in arranging programs for this meeting are the Aviation, Wood Industries, Power, Hydraulic, Management, and Production Engineering.

Headquarters at Hotel Blackhawk

Arrangements have been made with the Hotel Blackhawk as headquarters, where all technical sessions will be held. This hotel management also operates the Hotel Mississippi a block away and the Hotel Davenport two blocks away, and it is prepared to accept reservations now. Members are encouraged to make such reservations as soon as they decide to attend the meeting, for it is often easier to cancel a reservation than it is to make one at a late date. In asking for reservations mention should be made that it is in connection with the A.S.M.E. Spring Meeting.

Plant-Trip Arrangements

The question of plant trips during wartime is an important one and one which requires that members be prepared to present birth certificates or other credentials of citizenship. It will be helpful, therefore, if those who contemplate attendance at the Meeting will be so thoughtful as to advise the Secretary's office at once. Lists of such members with their titles and company connections will be of great aid in making arrangements for visits to the local industries, including perhaps the Arsenal.

A.S.M.E. Calendar

of Coming Meetings

April 26–28, 1943
Spring Meeting
Davenport, Iowa

June 14–16, 1943
Semi-Annual Meeting
Los Angeles, Calif.

June, 1943
Applied Mechanics Division
Pittsburgh, Pa.

June, 1943
Oil and Gas Power Division
Baltimore, Md.

(For coming meetings of other organizations see page 34 of the advertising section of this issue)

Edison Medal Awarded to Edwin Howard Armstrong

THE Edison Medal for 1942 has been awarded by the American Institute of Electrical Engineers to Doctor Edwin Howard Armstrong, professor of electrical engineering, Columbia University, "for distinguished contributions to the art of electric communication, notably the regenerative circuit, the superheterodyne, and frequency modulation."

The medal will be presented to Dr. Armstrong on Wednesday evening, January 27, 1943, in the Engineering Auditorium, 33 West 39th Street, New York, N. Y., during the National Technical meeting of the American Institute of Electrical Engineers to be held in the Engineering Societies Building, January 25–29, 1943.

The Edison Medal was founded by associates and friends of Thomas A. Edison and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

Dr. Armstrong was awarded the Holley Medal of the A.S.M.E. in 1940.

J. F. Metten Heads Naval Architects

THE election of John F. Metten as president of The Society of Naval Architects and Marine Engineers for a term of two years, beginning January 1, 1943, has been announced.

Sikorsky to Receive Reed Award for 1942

IGOR I. SIKORSKY, noted aircraft designer and engineer, has been elected an Honorary Fellow of the Institute of the Aeronautical Sciences and has been chosen to receive its annual Sylvanus Albert Reed Award for 1942. Mr. Sikorsky is engineering manager of the Vought-Sikorsky Aircraft Division of the United Aircraft Corporation, Stratford, Conn., with which concern he has been associated since 1928.

Honorary Fellowship is the Institute's highest honor, conferred in recognition of preeminence in aeronautics. It has been conferred upon only eighteen persons since the formation of the Institute. The Reed Award, with honorarium of $250, is given each year for a notable contribution to the aeronautical sciences whose practical value is apparent. Mr. Sikorsky will receive the Award with the citation "for the creation and reduction to successful practice of a helicopter of superior controllability."

Lawrence Sperry Award to Edward C. Wells

EDWARD C. WELLS, of the Boeing Aircraft Company, Seattle, will receive the Lawrence Sperry Award for 1942 of the Institute of the Aeronautical Sciences. The award is given annually for notable accomplishments by young men in the advancement of aeronautics.

Mr. Wells, who has been associated with the Boeing company since his graduation, was appointed assistant chief engineer in 1939 at the age of 28. He is responsible for much of the design and engineering work on the "Flying Fortress" B-17 Army bombers.

The Sperry Award will be given to Mr. Wells with the citation "for outstanding contributions to the art of airplane design with special reference to four-engined aircraft." Carrying an honorarium of $250, the Award is endowed by the brothers and sister of the late Lawrence Sperry, pioneer aviator and inventor, who was drowned at the age of 31 as the result of a forced landing in the English Channel in 1923.

R. C. Muir Honored at Manhattan College

THE School of Engineering, Manhattan College, New York, N. Y., celebrated its fiftieth anniversary on October 14, 1942. Dean R. L. Sackett represented The American Society of Mechanical Engineers at the celebration.

R. C. Muir, vice-president, General Electric Company, and member A.S.M.E., received the honorary degree of Doctor of Engineering at the exercises and delivered the principal address which was entitled "The Industrial Aspect of Technology—Effect Upon Economic and Social Structure With Emphasis on Present Planning and Future Readjustment."

Many Technical Sessions Held During 1942 Annual Meeting

Research, Standards, Power Test, Safety, and Boiler Codes Represented

THIS year, as usual, the technical sessions of the Annual Meeting were paralleled by a group of 34 technical-committee meetings. These meetings extended from Monday morning to Friday evening. They were divided among the several groups as follows: Research, 10; Standards, 13; Power Test Codes, 6; Safety, 4; and Boiler Code, 1. The attendance at these committee meetings was exceptionally good. The total number present was 382.

THE RESEARCH GROUP:

Ten special and joint research committee meetings were held during the five days of Annual Meeting week. They were all well attended and in each case good progress was recorded. The research group of committee meetings was opened Monday morning by the Special Research Committee on the Forging of Steel Shells, M. D. Stone, chairman. A large percentage of the membership was present and the meeting was in session the entire day. That evening the A.S.M.E. Research Committee and the Power Division sponsored a technical session on the subject of "Tube Expanding" at which T. B. Allardice presided and H. Weisberg, a member of the standing committee, served as recorder. The three papers presented at that session were: "The Holding Power and Hydraulic Tightness of Expanded Tube Joints; Analysis of the Stress and Deformation," by J. N. Goodier and G. J. Schoessow; "Experimental Investigation of Tube Expanding," by E. D. Grimison and G. H. Lee; and "Practical Aspects of Making Expanded Joints," by Carl A. Maxwell.

Lubrication

The Special Research Committee on Lubrication held its annual meeting on Tuesday morning. G. B. Karelitz, chairman, and S. J. Needs, secretary, were in charge and ten members of the committee were present. That afternoon this committee sponsored a technical session at which L. C. Kemp, Jr., presided and L. M. Tichvinsky acted as recorder. The following two papers were presented and discussed at this session: "Static Friction," by Walter Claypoole, and "Experiments on Bearing Performance," by R. J. S. Pigott, Paul G. Exline, and W. E. Kramer.

Fluid Meters

Tuesday morning the Society's oldest special research committee, that on Fluid Meters, conducted a technical session with its chairman, R. J. S. Pigott, in the chair and its secretary, J. R. Carlton, serving as recorder. Three papers were presented at this session, one by W. S. Pardoe on "The Effect of Installation on the Coefficients of Venturi Meters;" one by R. J. S. Pigott, E. W. Jacobson, and E. E. Ambrosius on "Results of Tests on Volumeters for Liquid Hydrocarbons;" and the third by S. R. Beitler, E. J. Lindahl, and H. B. McNichols on "Developments in the Measuring of Pulsating Flows With Inferential Head Meters." A well-attended meeting of this special research committee was held that afternoon at which reports were received on the studies of flow nozzles, volumeters, and the effect of pulsations on inferential head meters.

Main Research Committee

Also on Tuesday afternoon the A.S.M.E. Research Committee, the standing committee of the Society in charge of this activity, held its annual meeting. All five of its members, W. Trinks, M. D. Hersey, Herman Weisberg, W. R. Elsey, and J. F. Downie Smith, were present and in addition 17 A.S.M.E. members interested in its research activity including the following five members of the committee's advisory group: A. D. Bailey, E. G. Bailey, N. E. Funk, A. A. Potter, and L. W. Wallace. A considerable amount of routine business was transacted and reports were received from six of the secretaries of the professional divisions and from nine officers of the 16 special and joint research committees. One item on the order of business was the election of the chairman for 1943. Professor Trinks, the retiring chairman, called for nominations and M. D. Hersey was unanimously elected. It was announced, too, that President-Elect H. V. Coes had approved the appointment of David L. Lindquist to membership on the standing committee.

Strength of Vessels

On Wednesday morning ten members of the Special Research Committee on Strength of Vessels Under External Pressure were at work on their problem. F. V. Hartman is chairman of this committee. That day two committees held luncheon meetings. These were the Special Research Committee on Rolling of Steel, A. Nádai, chairman; and the Subcommittee on Feedwater—Care of Power Boilers—of the Boiler Code Committee. Three technical sessions were scheduled also for Wednesday under the auspices of special and joint research committees or jointly with a professional division. In the morning the Special Research Committee on Rolling of Steel joined with the Applied Mechanics Division in presenting the following three interesting papers: "Creep and Relaxation of Oxygen-Free Copper," by E. A. Davis; "A Principle of Maximum Plastic Resistance," by M. A. Sadowsky; and "The Distribution of Strains in the Rolling Process," by C. W. MacGregor and L. F. Coffin, Jr. Prof. W. Trinks served as chairman and M. D. Stone as recorder. At the same hour the Power Division co-operated with the Joint Research Committee on Boiler Feedwater Studies in putting on a panel discussion on boiler-water problems in connection with high-temperature, high-pressure steam generation. The following 12 experts sat in a row on the platform behind cards which carried their names in large letters: B. O. Buckland, W. E. Caldwell, C. B. Campbell, O. F. Campbell, L. E. Hankison, E. Mandel, E. P. Partridge, S. T. Powell, T. E. Purcell, W. C. Schroeder, S. E. Tray, and S. F. Whirl. The chairman was C. H. Fellows, and H. C. Miller was recorder.

Boiler Feedwater

On Wednesday afternoon the Joint Research Committee on Boiler Feedwater Studies sponsored a session at which two papers were presented, one, "A Practical Way to Prevent Embrittlement Cracking," by A. A. Berk and W. C. Schroeder, and "Boiler Embrittlement," by Carl A. Zapffe. S. T. Powell presided and J. B. Romer served as recorder.

Cracking of Boiler Metal

The Subcommittee on Effect of Solution Composition on the Cracking of Boiler Metal, of the Joint Research Committee on Boiler Feedwater Studies, J. H. Walker, chairman, held its annual business meeting on Thursday morning. The Executive Committee of the Joint Research Committee on Boiler Feedwater Studies, C. H. Fellows, chairman, held its annual business meeting that afternoon. The same afternoon the Special Research Committee on Mechanical Springs held a spirited session with nine members present. J. R. Townsend is chairman of this committee and C. T. Edgerton is its secretary.

Mechanical Springs

Two technical sessions sponsored by research committees were held on Thursday, the one during the morning period being sponsored by the Special Research Committee on Mechanical Springs, at which three papers were presented. These were "Volute-Spring Formulas," by C. J. Holland; "The Testing of Volute Springs," by Bernhard Sterne; and "Notes on Secondary Stresses in Volute Springs," by Henry O. Fuchs. At the evening sessions two research committees joined in the arrangements for a session on Corrosion and Deoxidation of Alloy Steels. These committees were the Special Research Committee on Critical Pressure Steam Boilers and the Joint Research Committee on the Effect of Temperature on the Properties of Metals. The two papers presented were "Corrosion of Unstressed Alloy-Steel Specimens by Steam at Temperatures up to 1800 F," by G. A. Hawkins, H. L. Solberg, J. T. Agnew, and A. A. Potter; and "Effect of Deoxidation Practice on Creep Strength of Carbon-Molybdenum Steel at 850 and 1000 F," by Richard F. Miller. H. J. Kerr presided at the session and E. L. Robinson served as recorder.

Furnace-Heat Transmission

One of the technical sessions on Friday morning was under the auspices of the Research Committee with the co-operation of the Fuels, Power, and Heat Transfer divisions and was scheduled for the purpose of discussing

a paper on furnace-heat transmission presented before the 1941 Annual Meeting. This paper was entitled "Studies of Heat Transmission Through Boiler Tubing at Pressures from 500 to 3300 Pounds," by W. F. Davidson, P. H. Hardie, C. G. Humphreys, A. A. Markson, A. R. Mumford, and T. Ravese. E. G. Bailey presided and H. Weisberg was the recorder.

On Friday afternoon the Special Research Committee on Furnace Performance Factors, A. R. Mumford, chairman, held its meeting at which 12 members of the committee were present.

STANDARDS GROUP:

As in previous years the A.S.M.E. Standardization Committee opened the group of standards committee meetings by a well-attended meeting on Monday morning. This was the annual meeting of the committee and it received the report of C. B. LePage, secretary, and conducted routine business. One important item in the secretary's report was the statement that during the Society's fiscal year ten standards had been completed or revised and transmitted to the American Standards Association. It was reported also that at the time of the meeting five additional standards had been completed by the sectional committees and were passing through the final approvals required by the procedure of the A.S.A.

The progress made by the other standards committees for which the Society is sponsor or joint sponsor is recorded in the standing committee's annual report which is published as a part of a separate pamphlet available on application to A.S.M.E. headquarters.

Another item on the order of business was the election of the new chairman of the committee. J. E. Lovely, the retiring chairman, called for nominations and L. T. Knocke was nominated and unanimously elected chairman for the year 1942–1943. The committee was then informed that President H. V. Coes had approved its recommendation for the appointment of E. J. Bryant as the 1942 addition to the committee's personnel.

Tools—Machine-Tool Elements

By far the largest group of standards committees to hold meetings this year is that organized by the Sectional Committee on the Standardization of Small Tools and Machine Tool Elements, B5, of which W. C. Mueller is chairman and P. L. Houser is secretary. In all, six meetings were held including the annual meeting of the sectional committee.

Technical Committee No. 10 on Forming Tools and Holders led off with a meeting Monday afternoon. W. C. Mueller presided as chairman. This committee is now at work preparing a draft of an American Standard for Straight Cutoff Blades for Lathes and Screw Machines.

On Tuesday morning Technical Committee No. 9 on Punch Press Tools, of which C. D. Carter is chairman, held its meeting with six in attendance. At the same hour nine attended the meeting of Technical Committee No. 21 on Tool-Life Tests for Single-Point Tools, of which O. W. Boston is chairman.

On the afternoon of that day Technical Committee No. 2 on Tool Posts and Tool Shanks held its meeting and completed its revision of the present American Standard B5b-1929.

Good progress was made by the Subgroup on Straight Splines (Technical Committee No. 13) of which J. B. Armitage is chairman. This meeting was held on Wednesday morning with eight present.

Thursday afternoon was the time set for the annual meeting of Sectional Committee B5. At this meeting the sectional committee receives the reports of its technical committees. The most active committees during the past year were: tool posts and tool shanks, forming tools and holders, splines, twist drills, and machine tapers. Nineteen were present at this meeting.

Therbligs, Process Charts, Symbols

The new standards committee on Therbligs, Process Charts, and Their Symbols held its organization meeting on Monday afternoon with Chairman D. B. Porter in the chair. Five of the nine members attended.

On Tuesday morning the subcommittee of Sectional Committee B32 received the report of its subgroup which had formulated a proposed American Standard for the Preferred Sizes of Bare and Metallic Coated Round Wire. During the year since the last meeting this subgroup had distributed its proposal generally to industry for criticism and comment so the report on the results of this canvass was received with interest. Refer to the "Standards Column" in the advertising section of the January issue of MECHANICAL ENGINEERING for further details.

Surface Qualities

The largest attendance at the standards committee meetings was at the all-day meeting of the new Subcommittee on Revision and Editing of the Sectional Committee on the Standardization of Classification and Designation of Surface Qualities, B46. R. F. Gagg, chairman of both committees, presided and the attendance reached thirty-two at the morning session. This meeting was first planned as an executive session of the special subcommittee appointed last June to review the draft of the proposed standard prepared by Secretary H. J. Griffing. However, the meeting was finally opened to members of the sectional committee who also had received copies of the new draft standard.

Drawing, Drafting-Room Practice

The subcommittee in charge of the revision and extension of the present American Standard for Drawing and Drafting-Room Practice, Z14.1–1935, completed its first tentative report and copies were mailed to the members of Sectional Committee Z14 for critical review in November, 1942. A meeting of Sectional Committee Z14 was called, therefore, to give its members a first opportunity to discuss this tentative draft. The meeting was presided over by T. E. French, chairman of Sectional Committee Z14, and F. G. Higbee, chairman of the subcommittee, served as secretary. Twenty were in attendance.

Spring Washers—Plumbing

On Friday at the Engineering Societies Building the Subcommittee on Spring Washers of Sectional Committee B27 held a meeting at which nine were present. E. D. Cowlin, chairman, presided and progress toward the completion of the subcommittee's report was made.

On Friday also eleven of the fourteen members of the subgroup which is drafting the proposed American Standard Plumbing Code held an all-day meeting at the Hotel Astor. The time was spent in revising a preliminary draft of Section 10 on Drainage-Soil, Waste, and Vent, and Section 11 on Drainage—House Drains and Sewers. A. H. Morgan, chairman of the subgroup, presided throughout the day.

POWER TEST CODES GROUP:

The Power Test Codes group of technical committee meetings numbered six this year. The first was held on Tuesday afternoon when thirteen persons attended a meeting of PTC Committee No. 4 on Stationary Steam-Generating Units. Chairman E. R. Fish presided and the committee later announced the completion of the revision of the Test Code for Stationary Steam-Generating Units.

Definitions and Values

The finishing touches were put on the revision of "Definitions and Values" by PTC Committee No. 2, R. J. S. Pigott, chairman, on Wednesday morning. That afternoon two power test codes committees held meetings. PTC Committee No. 18, S. Logan Kerr, chairman, gathered eight members together to discuss certain questions connected with the supplements to the Test Code for Hydraulic Prime Movers. The second meeting was held by PTC Committee No. 13 on Refrigerating Systems, B. H. Jennings, chairman.

The annual get-together of all those at work on power test codes for the Society was held this year on Thursday morning. Invitations had been previously sent to 205 members of the Society and other specialists included in this group of workers. Thirty seven were present at the meeting. Francis Hodgkinson, chairman of the standing committee, presided. Oral reports were received from the officers of the technical committees present and other routine business was transacted.

On the following Friday morning eight members of PTC Committee No. 17 on Internal-Combustion Engines, Lee Schneitter, chairman, met to review the revised draft of the proposed new code, copies of which had been distributed in November.

SAFETY GROUP:

During Annual Meeting week the Executive Committee of the Sectional Committee on the Safety Code for Elevators held two meetings in the Engineering Societies Building on Wednesday and Thursday afternoons, respectively. On Friday afternoon at the same place the Subcommittee on Elevator Inspectors' Manual held a meeting at which eleven members were present.

The Annual Meeting of the A.S.M.E. Safety Committee was held on Thursday afternoon at the Hotel Astor. Chairman A. W. Luce presided and routine business occupied most of the time of the meeting. A. E. Windle was elected chairman for the coming year and it was announced that Capt. J. R. Connelly had been appointed by President-elect H. V. Coes to serve for the five-year term beginning December, 1942.

Nominating Committee Urges Members to Suggest Nominees for Office in 1944

Suggestions to be on file not later than April 1, 1943

THE 1943 Nominating Committee urges the members of the A.S.M.E. to give serious consideration to the selection of nominees for elective offices in 1944 and to submit their suggestions promptly not later than April 1, 1943.

The offices to be filled are President (to serve one year), four Vice-Presidents (to serve two years), and three Managers (to serve three years). The Constitution, By-Laws, and Rules of the Society, Articles C7, B7, and R7 govern the election of directors.

Forms Will Be Furnished by the Nominating Committee

It is not the duty of the Nominating Committee to solicit nominations, hence no communications will be sent out to Local Sections by the Nominating Committee. The procedure for suggesting nominees to the Committee is to write to the Secretary of the Nominating Committee to obtain the proper forms.

At its organization meeting in December, the Nominating Committee agreed to furnish forms for the convenience of those wishing to suggest nominees. This form contains spaces for most of the information which is essential to full consideration of each proposed nominee. Because the Nominating Committee operates with only meager funds it is requested that eight copies of the form be turned in to the Secretary of the Nominating Committee who will in turn see that each member of the Committee is properly informed. It is unnecessary to have additional forms for endorsers, but the Committee will welcome eight copies of a letter of endorsement from those wishing to support any suggested nominee.

This form when properly filled out presents a list of the activities of the proposed nominees within the Society as well as in other professional and nonprofessional organizations. The candidate's sponsor should obtain preliminary assurance of willingness and freedom to serve if elected. National professional prominence and leadership are essential to able leadership of the Society. Knowledge of Society affairs and management obtained by previous service on committees is important in enabling the successful candidate to render service to the best of his real ability. The nominees for president and vice-presidents must be of the member or fellow grade; managers may be of any grade of membership.

Those who require additional information to complete the filling out of the nominating form are invited to write to Ernest Hartford, Executive Assistant Secretary, A.S.M.E., 29 West 39th St., New York, N. Y.

B. P. Graves Elected Chairman

At the organization meeting of the 1943 Nominating Committee on December 3, 1942, B. P. Graves was elected chairman and Warner Seely was elected secretary. The names of all of the members of the Nominating Committee, the Group they represent, and their addresses are given on this page.

The 1943 A.S.M.E. Nominating Committee

GROUP I
Representative—B. P. Graves, Chairman, Brown & Sharpe Manufacturing Co., Providence, R. I.
1st Alternate —L. C. Smith, Spencer Turbine Co., Hartford, Conn.
2nd Alternate —C. P. Howard, 18 Davidson Rd., Worcester, Mass.

II
Representative—Theodore Baumeister, Columbia University, New York, N. Y.
1st Alternate —G. J. Nicastro, Combustion Engineering Co., Inc., 200 Madison Ave., New York, N. Y.

III
Representative—V. M. Palmer, Eastman Kodak Co., 1669 Lake Avenue, Rochester, N. Y.
1st Alternate —J. S. Morehouse, Villanova College, Villanova, Pa.
2nd Alternate —C. H. Bierbaum, 197 Lathrop St., Buffalo, N. Y.

IV
Representative—James Ellis, 1708 Orchard Lane, Kingsport, Tenn.
1st Alternate —A. M. Ormond, Savannah Sugar Refining Corporation, Savannah, Ga.
2nd Alternate —H. G. Mouat, Whiting Corporation, 830 Martin Building, Birmingham, Ala.

V
Representative—Warner Seely, Secretary, Warner & Swasey Co., 5701 Carnegie Avenue, Cleveland, Ohio
1st Alternate E. R. McCarthy, 3077 Meadowbrook Boulevard, Cleveland Heights, Ohio
2nd Alternate —S. M. Weckstein, 204 25th Street, N. W., Canton, Ohio

VI
Representative—G. L. Larson, Department of Mechanical Engineering, University of Wisconsin, Madison, Wis.
1st Alternate —David Larkin, 4203 North Union Boulevard, St. Louis, Mo.
2nd Alternate —W. C. Lindemann, 601 Cleveland, Ave., Milwaukee, Wis.

VII
Representative—L. T. Hays, Box 3416, Portland, Ore.
1st Alternate —E. P. Weiser, 7412 N. Chase, Portland, Ore.

VIII
Representative—A. L. Hill, 1033 Humboldt St., Denver, Col.
1st Alternate —H. L. Crain, Kansas City Power & Light Co., 115 Grand Ave., Kansas City, Mo.
2nd Alternate —H. E. Degler, University of Texas, Austin, Texas

A.S.A. Announces Inter-American Program

TRADE and industrial development of the Americas will be furthered by a program of Inter-American co-operation on industrial and engineering standards which has just been launched by the American Standards Association.

Full-fledged national standardizing bodies are now in operation in three South American countries. The one in Argentina (Instituto Argentino de Racionalización de Materiales) has been operating a number of years and publishes a monthly magazine. The one in Brazil (Associacao Brasileira de Normas Técnicas) has recently issued a volume of standards. The one in Uruguay (Instituto Uruguayo de Normas Técnicas) was formed a short time ago. In other Latin American countries there are government departments and engineering societies doing similar work. Furthermore, there is a South American committee (Comité Sudamericano de Normas) to further standardization work in the ten South American republics.

Cyrus Townsend Brady, Jr., an engineer and sales executive who has spent many years in South America, will serve as the field representative for the American Standards Association. Mr. Brady's work will be supported by an Inter-American Division in the New York office of the A.S.A., headed by Alberto Magno-Rodrigues, who has been for many years in charge of the activities of several American manufacturers of machinery in the Spanish and Portuguese markets.

Among the Local Sections

Ladies' Night at Akron-Canton

THE Dec. 10 meeting of Akron-Canton Section was a social one. Speakers of the evening were Paton Edwards, who gave an excellent chalk talk, and Purv Pulen, well known radio and screen performer, formerly with Ben Bernie, Jack Benny, Screen Guild, and other programs. The evening proved thoroughly enjoyable for all.

Engineering Ideas Needed in War Effort, Topic at Central Illinois

More than 100 members and guests at the Dec. 10 meeting of the Central Illinois Section heard J. R. Boyle on the subject, "Engineering Inventions and Ideas Needed in Our War Effort." In his address, the speaker categorized some forty different developments now urgently needed in our war effort. He outlined ideas that have been turned in to the Chicago War Production Board Committee, telling how the committee helps shape up such ideas for practical use in production.

Chicago Section Holds Two December Meetings

On Dec. 8, members of the Chicago Section had as their speaker of the evening Major James S. Harvey, who gave an account of the operations of the Industrial Security Division, which inspects and advises on the precautionary measures applicable to war plants, military warehouses, arsenals, and depots.

"The Diesel Engine in Railroad Transportation" was the subject on Dec. 14. Ernest Kuehn reviewed the gradually successful application of the Diesel engine to the economic problems of the railroads, both in terminal work and in line hauling of both passenger and freight trains. His intimate contact with the modern Diesel-locomotive developments and his recounting of personal experiences made the meeting very interesting indeed.

Sikorsky Attracts 350 at Cleveland Session

Igor Sikorsky spoke to a gathering of 350 members and guests at the Dec. 10 meeting of Cleveland Section. His subject was "Recent Developments in Direct-Lift Aircraft" in which he presented with movies a description of the helicopter and its operation, along with predictions of its postwar use.

Airplane Design at Columbus

"Airplane Design" was B. G. Eaton's topic at the Dec. 11 meeting of Columbus Section. The speaker, development engineer at Curtiss-Wright Corporation, traced the design of an airplane with the aid of slides and answered countless questions on airplane construction.

At Detroit, Future Transportation

More than 150 members and guests heard Wm. S. Stout at the Dec. 1 meeting of Detroit Section. The speaker prefaced his talk with a reference to the past and present aspects of aircraft use. Regarding future developments in aircraft transportation, Mr. Stout expressed the belief that future traffic channels for air use will exceed the present ones in size and speed, as well as being lower in cost. In the field of small planes, he spoke of the increased future use of the helicopter in short-range flights.

The Detroit Junior Group heard Donald J. Sablette, secretary and chief examiner of the Detroit Civil Service Commission at the Dec. 15 meeting. His talk, "Personnel Administration—A Technique of Engineering Management," began with definitions and pointed out the state of the arts in psychological measurement. He gave examples of the effect of personnel considerations on the work of the design engineer.

East Tennessee Section Hears Thought-Provoking Topic

To an interested audience of 65 members and guests of East Tennessee Section, Col. James L. Walsh spoke, Dec. 16, on "The Science of Survival." Many provocative ideas were mentioned.

Science of Survival at Greenville

In his address at the Dec. 15 meeting of Greenville Section, Col. James L. Walsh sketched how we were caught short in World War I for lack of ordnance, how we caught up, the mistakes we made, etc. Then he sketched how we benefited from our mistakes of World War I in the current war and gave encouraging facts and figures showing how well our supply of ordnance is now being taken care of by our government and our allies.

Metal-Powder Products at Ithaca Section

Members and guests of Ithaca Section at the Dec. 15 meeting heard Jerome F. Kurzmich of Stevens Institute discuss "The Development of Metal-Powder Products." He spoke at considerable length on the methods of preparing and using the same in different applications of powder metallurgy. He also showed slides of sections of metal-powder products, showing the structure of such materials.

The Victory Twins Come to Kansas

"The Victory Twins—Electricity and Oil" was the subject at the Dec. 10 meeting of Kansas Section. The speaker, H. E. Dralle of Westinghouse Electric and Manufacturing Co., presented his very enlightening talk to a joint meeting of the A.S.M.E. and other engineering groups. He traced the history of the oil industry, showing the progress that has been made in the last 75 years, and its vital necessity in our present war effort. The close relation of electricity and oil in this effort was stressed. The speaker included facts and figures on the emergency oil lines now being laid. Many graphic illustrations contributed to the vital interest of this timely topic.

Los Angeles Section Members Inspect Kaiser Steel Mill

More than 120 members and guests of Kansas Section inspected the Kaiser Steel Mill at Fontana, Calif., on Dec. 17. A brief introductory talk was given by J. Calvin Brown, chairman, introducing John Stuler, executive assistant of the company, Walter Farrell, and Jack Burwell of the public relations department. The trip proved very interesting.

Mid-Continent Section Learns About Sponge Iron

A record audience of 100 heard H. G. S. Anderson, at the Dec. 21 meeting, speak on the topic "Sponge Iron." The speaker said that the topic of sponge iron has become a "hot one" both metallurgically and politically. The metallurgists' recommendation to the W.P.B. that 100-ton sponge-iron plants be built in the gas fields of the mid-continent and southwestern states brought disapproval from $1 a year advisers in the steel and iron sections of W.P.B. Finally through the aid of the Dancigers of the Danciger Oil and Refining Co. of Tulsa, Okla., Mr. Anderson finally convinced some of the W.P.B. men that they were wrong in excluding such a process in supplying the nation with an adequate supply of the cheaply produced and usable iron.

He went on to say that one ton of metallurgical coke will make a ton of pig iron in the blast furnace, but with his process he could make a ton of sponge iron with from 25,000 to 30,000 cubic feet of natural gas. The speaker concluded with the remark that he was now working with the American Committee in Aid of Chinese Industrial Co-operatives and designing a sponge-iron plant for the Republic of China.

Aerial Bombardment, at Milwaukee Section

"Aerial Bombardment and Sabotage Protection" constituted an interesting program at the Dec. 9 meeting of Milwaukee Section. Prof. O. Neil Olson, head of the civil-engineering department of Marquette University, was the guest of the evening. His lecture stressed the phases of protection from sabotage

and bombardment. He accompanied his talk with slides revealing damage wrought in Europe and China.

New Haven Holds Organization for War Production Board Conference

The Dec. 17 meeting of New Haven Section concerned itself with setting forth the aims of the proposed W.P.B. conference and explaining what had been done to date. C. A. Newton of W.P.B. remarked that the "allocation of materials plan" is a knotty problem with manufacturers. His suggestions on topics included the problem of fuel-oil conversion, helping small plants get contracts, an inventory of liquid material, material salvage, priorities, and women workers. Various other representatives of W.P.B. outlined further problems, such as small-plant conversion, national-emergency steels, heat-treating, and powdered metals. Ways in which the A.S.M.E. could help were mentioned. These included supplying skilled experts capable of answering technical questions, obtaining discussion leaders, and providing channels through which trained men may meet those in need of their services.

Welding Problems Head Bill At Norwich Section

To an enthusiastic audience of members and guests of Norwich Section on Dec. 17, James Partington spoke on the topic, "Welding Problems of Steam, Electric, and Diesel-Electric Locomotives." In this talk he described the uses of welding in fabricating locomotive frames, tender tanks, firebox door rings, etc. He described the construction of a boiler welded throughout and stress-relieved under American Welding Society rules, which is undergoing a five-year test and giving splendid service. An interesting question period followed the talk.

Helicopter Flies High at Philadelphia Section

At the Dec. 8 meeting Philadelphia Section heard C. L. Morris, engineering test pilot for Sikorsky, on the subject, "Development of the Sikorsky Helicopter." In addition to the talk, a movie further demonstrated the maneuverability of this plane.

Science of Survival Featured at Raleigh

More than 80 members and guests of Raleigh Section heard Col. James L. Walsh on the subject of "Science of Survival" at its Dec. 8 meeting. The speaker outlined the three branches of military science strategy, tactics, and logistics. He pointed out some of the advantages the Axis had in length of supply lines. However, he named places where we could and have overcome these enemy advantages and told how the sum of all the acts of all the individuals in this country will determine who wins the war.

Southern California Section Inspects Kaiser Plant

As its Dec. 19 program, Southern California Section made an inspection tour of the Henry J. Kaiser Co. Plant at Fontana, Calif. On Dec. 30, a varied program was presented, consisting of the following speakers: Paul Backsdale d'Orr, state rationing officer, O.P.A., who spoke on "Rationing," Wm. H. Dudley, district gasoline rationing representative, O.P.A., who treated the topic "Gasoline Rationing," and Sam S. Hansen, chief industrial engineer for the General Petroleum Corporation of Southern California, who spoke on "Lubrication of Power-Plant Equipment."

St. Joseph Valley Engineers Hear About Steam Generation

To a record audience of 197 members and guests, E. G. Bailey, vice-president of Babcock and Wilcox Co. spoke, Dec. 15, on the subject of "Modern Steam Generation." His talk covered the development of boilers for higher temperatures and higher steam pressures, with particular reference to the Twin Branch plant of the Indiana and Michigan Electric Co. which supplies electric power locally. This plant has pressure of 2500 lb per sq in. Dr. Bailey's company built the equipment. A detailed explanation along with movies covered the fuel-combustion problem.

Joint Meeting at St. Louis on Industrial Engineering

The Dec. 18 meeting of St. Louis Section featured a panel discussion on the topic "The Functions of Industrial Engineering in Industry." Edgar H. Behle introduced Edward B. Freman who spoke as a mechanical engineer who started out as an industrial engineer. He said the function of the industrial engineer was developing and increasing production, managing efficient application of material and manpower. James Shoemaker talked on the early development of industrial engineering by A.S.M.E. members such as Taylor, Barth, Gilbreth, etc. Following the discussion, colored movies were shown.

Virginia Section Meets With Student Branch

At its Dec. 7 meeting, Virginia Section joined with the Student Branch to hear Col. James L. Walsh, who addressed more than 175 members and students. The second meeting of the month, on Dec. 17, was held jointly with the Central Virginia Engineers' Club, Richmond, again to hear Colonel Walsh.

Industrial Electronics at Western Massachusetts

A responsive audience greeted W. C. Hutchins, manager of the laboratory products section, G. E. Co., Schenectady, N. Y., and Howard Clark, G. E. laboratories, at the Dec. 15 meeting of Western Massachusetts Section. The first speaker opened the discussion by reviewing the history of the electron tube from 25 years ago when scientists used it as a laboratory tool, through its present use in radio broadcasting. Electronics itself has been employed in industry for about ten years, with the photoelectric tube being the oldest. Its future utilization will be for purposes now unimaginable. Numerous slides were shown illustrating the industrial application of electronics in many fields of industry. The second speaker demonstrated the various devices which they had set up, consisting of the application to a school room for controlling even intensities of light on dark and light days, a vibration-measurement instrument, a recording device, a device for indicating and controlling the proper amount of light used in photographic work, and a device for checking the frequency of an electrical system. A short question period followed.

President H. V. Coes Pays His First Visit to Sections

AS we go to press word has been received from the St. Louis Section of the Society that at a dinner on January 12 at the Hotel Statler, arranged in honor of the visit by President H. V. Coes, there were present many of the present and past officers of the Section among whom were past-chairmen Edward Flad, L. A. Day, E. H. Tenney, W. E. Bryan, L. C. Farquhar, J. R. Jackson, R. M. Boyles, David Larkin, Charles C. Colley, Albert Vigne, and R. W. Merke. Other past officers included R. R. Tucker, Walter Siegerist, Dean A. S. Langsdorf of Washington University, Schools of Engineering and Architecture.

On January 13 President Coes addressed the A.S.M.E. Student Branch at Washington University (St. Louis) and on the following day the Student Branch at the University of Missouri in Columbus, Mo.

This is the first of President Coes' trips to the Local Sections and Student Branches, and members of the St. Louis Section were proud of the honor paid them.

Midwest Power Conference to Be Held in Chicago, April 9-10

IT HAS been announced that the Midwest Power Conference will be held in Chicago, April 9 and 10, 1943, with headquarters probably at the Palmer House.

Prof. Stanton E. Winston, director of the conference, has announced that C. W. Kellogg, president of Edison Electric Institute, will be the keynote speaker. "Power for Victory" has been adopted as the motto of the 1943 conference. Col. James L. Walsh, chairman of the A.S.M.E. War Production Committee, will address the All Engineers' Dinner on the subject "Logistics, the Science of Survival."

The conference is sponsored by the Illinois Institute of Technology, nine other engineering schools, and sections of seven national engineering societies, of which the Chicago Section of the A.S.M.E. is one.

A.S.M.E. STUDENT BRANCH DANCE AT A.P.I., DEC. 4, 1942

With the Student Branches

200 Attend Alabama Poly Dance

ALABAMA POLY BRANCH gave a dance on Dec. 4 to which all mechanical and aeronautical engineering students were invited. More than 200 attended the function. At the Dec. 14 session, a member of the Alabama State Department of Toxicology lectured to the Branch on the work of his department. With the aid of slides, the speaker explained the most modern methods of crime detection, including the determination of the gun from which a particular fatal bullet was fired.

ARIZONA BRANCH held a dinner meeting on Dec. 16. Chairman Fred Fiedler acted as toastmaster and asked each person present to introduce himself. Then he presented the speaker of the evening, Capt. John H. Glamser, Air Corps, U.S. Army, who gave an interesting talk on his work as engineer officer, such as inspections, investigations of "crack-ups," and engine failures. The talk was followed with the showing of a motion picture entitled "Fluid Drive."

DINNER MEETING OF A.S.M.E. STUDENT BRANCH AT ARIZONA, DEC. 16, 1942

BROOKLYN POLY BRANCH members met on Dec. 18 to view a motion picture furnished through the courtesy of the Aluminum Company of America. The January meeting of the Branch may be postponed or canceled due to the fact that midyear examinations will begin earlier than usual and it is felt that very few men can afford to detract themselves for even one hour for a meeting.

CALIFORNIA BRANCH at the session of Dec. 1 gave one-year subscriptions for *Life* and *Esquire* to the school's engineering library. Professor Levens spoke on the need of the country for graduate engineers and how one could find his place in the war effort. Pictures of the construction of the Consolidated "PB-Y" warplane were then shown, after which refreshments were served.

Case Mechanical Maneuvers Attract 160

A record crowd of more than 160 student members and "dates" turned out on Dec. 4 for the "Mechanical Maneuvers" sponsored by CASE BRANCH. The affair served a double purpose in that it was a farewell party for the seniors and a means of raising money for the redecoration of the A.S.M.E. recreation room. Featured on the program were movies, dancing, refreshments, reconnaissance trip (treasure hunt) with War Stamps as prizes, a drawing for a door prize of one quart of gasoline, war games, and a black-out room. Needless to say, everyone had a swell time.

CLEMSON BRANCH welcomed Col. James L. Walsh, member A.S.M.E., to its Dec. 15 meeting with a turnout of 259 members and guests. The Colonel described how we were "caught short" in World War I for lack of ordnance and how we were able to correct these mistakes with the beginning of World War II. His figures illustrated how our supply of ordnance is now being taken care of by our Government and Allies.

COLORADO STATE A.&M. BRANCH in conjunction with the A.I.E.E. and A.S.C.E. presented on Dec. 7 a three-reel sound film on the working of aluminum, including welding, riveting, and machining. The film vividly described and illustrated these processes, stressing the need for the proper working of aluminum in order to help conserve the nation's supply of this valuable metal.

Liberty Ships at Cooper Union

"Liberty Ship Propulsion" was the topic of John Meyers, chief engineer of Gibbs & Cox, in his address before the COOPER UNION BRANCH on Dec. 7. He stated that the rapidity of Liberty ship production was due to a large extent to the extreme simplicity and uniformity of the steam engines used for their propulsion. The talk was illustrated by photographic slides and wooden models of the engines.

CORNELL BRANCH held a joint meeting with the Ithaca Section of the A.S.M.E. on Dec. 15. The speaker of the evening was Jerome F. Kuzmick, assistant director of research, metal-powder laboratory, Stevens Institute of Technology. He spoke on the development of powdered-metal processes, their reasons for origin, and the methods of mass production of parts from powdered metal. To illustrate his lecture, he had numerous slides of presses, furnaces, and photomicrographs of sections of powdered metal. It was a very interesting lecture and was enjoyed by everyone.

FLORIDA BRANCH members attended a meeting of the Florida Section, A.S.M.E., in Jacksonville, Fla., on Nov. 20, and also made inspection trips to the plants of the National Container Co. and the Jacksonville power plant. An inspection trip was made to The American Lumber & Treating Co. in Gainesville on Dec. 12.

IDAHO BRANCH held a dinner meeting in the new mechanical-engineering laboratory on Dec. 16. H. C. Dale, president of the University, was guest speaker. Following the dinner, a picture of the group was taken, and a motion picture on shipbuilding, "Building the Keel Block," was shown.

IOWA STATE BRANCH met on Dec. 2 and viewed a motion picture entitled "Aluminum Fabrication."

KANSAS STATE BRANCH members numbering 48 were present at the Nov. 26 session and welcomed Prof. D. C. Warren, of the poultry husbandry department, as guest speaker, who presented a very novel and interesting film and lecture on the production of eggs in chickens.

TAKEN AT A SUMMER, 1942, MEETING OF A.S.M.E. STUDENT BRANCH AT CATHOLIC UNIVERSITY

(Standing is Col. Glen F. Jenks, Army Ordnance, member A.S.M.E., president of the American Welding Society. Seated from left to right: Prof. C. O. G. Wittig, honorary chairman, John J. Gormley, Jr., secretary, Prof. M. E. Weschler, past honorary chairman, and John D. Gallivan, 3rd, student chairman. This picture was taken after the meeting of August 26, 1942, and behind Colonel Jenks on the blackboard may be seen part of the sketches used by him in making points clear in his talk on "Arc Welding in the Present War.")

Kentucky Dean Talks About War

More than 200 members and guests of KENTUCKY BRANCH were present at the Dec. 4 meeting to hear Colonel James H. Graham, dean of the college of engineering, talk on the part of engineering students and engineers in the war effort. He began by stating that all those physically capable would certainly take an active part in the war before long and that the front lines are as safe as the rear. His suggested program for training students was as follows: (1) All students to be inducted and given 12 weeks of basic training, (2) following training, they would be sent back to college for a period up to seven quarters depending on individual ability, and (3) they would then go to officers' training school.

LOUISIANA STATE BRANCH followed its initiation week in November with a steak banquet at "Mike and Tony's," for old and new members. Frank Carroll, chairman of the Branch, served as toastmaster. The high light of the banquet was the after-dinner talk given by Dr. Hamilton Johnson, formerly head of the mechanical-engineering department at the University. The subject was "What Is an Engineer" and proved both interesting and helpful.

MAINE BRANCH held a combined meeting of the mechanical, electrical, and civil groups on Dec. 1 to hear a lecture by Wing Commander Asley Hall, R.A.F., who was visiting the University while on an inspection tour of the country. He spoke about the application of engineering to the building, maintenance, and operation of landing fields and planes.

MICHIGAN STATE BRANCH had more than 75 members and guests at its Dec. 1 session. The program consisted of a motion picture depicting the story of steel, from the mines to the finished product. It showed the various methods of mining, shipping, and refining of the ore. After the ore was refined into steel, the film showed how the various rolled structural shapes were made. These included channel irons, I-beams, angles, and many others. Also shown was the manufacture of wire and wire fencing and the fabrication of wheels and axles for railway cars.

MINNESOTA BRANCH held the final meeting of the fall quarter on Dec. 2. After the business part of the session had been disposed of, Lieut. Comdr. Joseph Flynn, of the Navy, spoke on "The Navy, Before and After Pearl Harbor."

Cigars Passed at Mississippi State

Prior to the start of the Nov. 24 meeting of MISSISSIPPI STATE BRANCH, cigars were passed to those present. Plans were then made for an old-fashioned hay ride to be followed with a feast of wienies, marshmallows, rolls, etc., to be held on Dec. 12.

MISSOURI MINES BRANCH elected officers at the Dec. 4 session. Prof. A. V. Kilpatrick was chosen honorary chairman.

MISSOURI BRANCH devoted the meeting of Dec. 3 to a discussion of plans for a banquet to be held on Jan. 13. Everyone would be welcome to come and see what a good time mechanical-engineering students have when they get together.

MONTANA STATE BRANCH heard on Dec. 3 that as a result of the membership drive 37 members had joined the Branch. Prof. F. C. Homann, of the mechanical-engineering department, gave a very interesting talk on the history and modern manufacture of guns. He had several examples and drawings of the development of small-bore guns and described a few of the techniques of present-day designing of large guns.

NEBRASKA BRANCH presented Professor De Baufre as the speaker on Dec. 3. In his talk, he traced the development of engineering education in the United States. He told of how in the 1880's it was possible to get an engineering degree by taking an arts and science course and then reading an extra book on engineering. A comparison was made with the intensive and exacting engineering courses being given today.

NEWARK BRANCH met on Dec. 4 and members recounted their experiences at the Annual Meeting of the A.S.M.E. in New York City during the previous week. Then, Lieut. John Brennan, U. S. Navy, spoke on shipbuilding and the testing of naval vessels. The talk was very educational and evoked considerable discussion among the members. The speaker was the first one which the Branch was able to obtain in a period of two months.

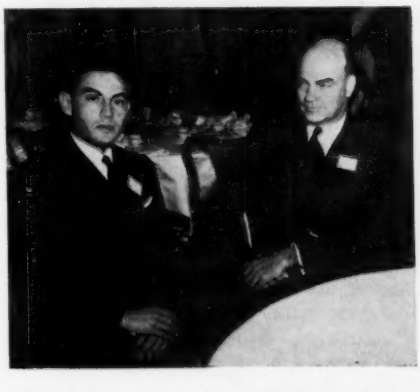
Student Addresses Northeastern

The first meeting of NORTHEASTERN BRANCH for the Division A members was held on Dec. 22. Speaker of the evening was a student member, Richard L. Divoll, who took as his topic, "Jigs and Fixtures." He described the different types of jigs and fixtures used and the many problems involved, such as obtaining desired accuracy, placing and removing of the work, allowances for cutting oil and chips.

OKLAHOMA BRANCH co-operated with the school authorities in reducing the number of meetings by holding a joint session with the other engineering groups on Dec. 10. Out of 76 present, 46 were A.S.M.E. members. A motion picture, entitled "Safe Flying," was shown through the courtesy of the N.A.C.A. The next item on the program was a talk on aircraft engines by Chief Specialist Mate Alexander Fish, of the U. S. Naval Training Station at Norman, Okla.

OKLAHOMA A.&M. BRANCH met on Nov. 23 to see the movie, "Coal Is King." C. M. Leonard then passed along to those present an offer of *Southern Power & Industry* to pay for articles contributed by students. John Buerer invited everyone to come to the mechanical-engineering laboratory to see the experiments and other activities being carried on there.

PURDUE BRANCH had more than 110 members and guests at the Dec. 8 session. Dr. G. A. Hawkins, professor of mechanical engineering at the University, and internationally known expert on high-pressure steam and heat transfer, addressed the Branch on the subject of "Photographing the Invisible." He illustrated his lecture with slides demonstrating



ENRIQUE F. SILGADO, RICE SCHOLAR ATTENDING CAL TECH, PHOTOGRAPHED WITH PRESIDENT JAMES W. PARKER AT 1942 A.S.M.E. ANNUAL MEETING

(Funds for Rice Scholarship are provided by A.S.M.E. Woman's Auxiliary.)

PART OF THE TUFTS GROUP OF STUDENTS ATTENDING THE 1942 ANNUAL MEETING

the principles and applications of infrared photography. Dr. Hawkins uses this technique of photography in his own research work in the field of heat transfer and, as a result of his own experiences, was able to explain in a most interesting manner many of the common applications and future potentialities of this type of photography.

Queen's Holds Interesting Sessions

"The Mechanical Engineer in the Army" was the subject of an address given by Maj. Gen. E. Schmidlin, head of the department of mechanical engineering, before 75 members and guests of QUEEN'S BRANCH on Nov. 3. He outlined the services performed by the three "engineering" services of the Canadian Army, namely, the Royal Canadian Ordnance Corps, Royal Canadian Engineers, and the Royal Canadian Army Service Corps. General Schmidlin then went on to sketch the function of the young engineer as a member of one of these services.

On the morning of Dec. 4, 27 members of the Branch visited the Canadian Locomotive Works and witnessed the fabrication of locomotives of the 4-6-2 type, the building of gun mounts, and the manufacture of tank wheels from armor plate. "Broaches, and Broach Design, With Applications to Wartime Production," was the topic of the talk given by Fred Schytte, chief engineer of the Illinois Tool Company, Toronto, before the members on Dec. 7. Outlining the fundamentals of broach design, with particular emphasis on the importance of chip control, Mr. Schytte demonstrated, with the aid of lantern slides, the problems and difficulties to be met by the successful broach designer.

ROSE POLY BRANCH held a meeting on Dec. 11 at which a movie, entitled "The Fourth Kingdom," was shown. The film illustrated the manufacture of plastics and their many applications.

SOUTH DAKOTA BRANCH exhibited at the Nov. 18 session two films on simple aerodynamics. After the discussion of plans for future meetings, the meeting was adjourned.

STANFORD BRANCH'S meeting of Dec. 2 took place at the home of Prof. L. Jacobsen, who exhibited and informally discussed his ancient-gun collection. Refreshments were served after the meeting.

SYRACUSE BRANCH held the first meeting of the semester on Nov. 11. Considerable business was transacted, including the nomination and election of officers, voting on by-laws, and preparation of plans for future sessions.

TENNESSEE BRANCH met on Dec. 3. Three interesting motion pictures on precision grinding were presented by Thomas Wright and Charles Cowan.

Toronto Has 101 Members

This year the student membership of TORONTO BRANCH has increased and now includes about 60 per cent of the total enrollment in the three senior years of mechanical engineering. At present there are 101 members and an increase of this number is expected within the next few weeks. Two successful meetings have been held thus far, one in October which was addressed by Prof. E. A. Allcut on the subject of "Gasoline Substitutes," and one in November which had as guest speaker, James W. Parker, President of the A.S.M.E., who spoke on our war effort as applied to the engineering profession.

TUFTS BRANCH held its second annual banquet on Nov. 10 with Walter R. Owens as toastmaster. Dean Burden and Professor MacNaughton made short speeches. A humorous version of "Who's Who in Senior Mechanical Engineering" was read by the toastmaster. At the finish of the meal, Jack Howard gave an illustrated lecture on hunting and fishing in the north woods. Twenty-five members of the Branch attended the Dec. 10 dinner and meeting of the Boston Section of the A.S.M.E. The speaker was Prof. Lionel S. Marks and his subject was "Recent Developments in Power Generation."

TULANE BRANCH held the third meeting of the semester on Dec. 10. At the session, John Burwell told of assembling B.&W. boilers on his summer job; John Cochrane described the Focke-Wulf 190 warplane; and Wally Diboll told of recent advancements in the field of metropolitan transportation. It was also decided at the meeting that every member will contribute one pint of blood to the Red Cross blood bank.

UTAH BRANCH met on Nov. 30 to bid farewell to the senior members who are graduating on Dec. 19 as a result of the accelerated program of war studies. However, the Branch will carry on as evidenced by the activity of the various committees.

V.P.I. BRANCH welcomed Colonel James L. Walsh to its Dec. 2 meeting. He spoke on the subject, "The Science of Survival."

Washington Meeting and Trip

The third meeting of the semester was held by WASHINGTON BRANCH on Nov. 20. Prof. Sybren R. Tymstra, guest speaker of the occasion, talked on the topic of "Gas Plants," which served as an introduction to a field trip taken by the members on Nov. 23 to the Lake Union Gas Plant of the Seattle Gas Company. The speaker, who had been active in this particular field and helped to solve many problems in connection with the construction and operation of this plant, briefly outlined the growing importance of gas in industry and the home. The main part of the paper was devoted to a description of the different types of modern gas plants and an explanation of the various stages and processes involved in the production of gas.

Bequest to Northwestern

IN excess of $20,000,000 will come to Northwestern University from the estate of Walter P. Murphy, manufacturer of railway supplies, who died on Dec. 16, 1942.

Mr. Murphy specified that the fund should be used to develop, maintain, and operate the Technological Institute of Northwestern University, which was founded in 1939 with a gift of $6,735,000 from the Walter P. Murphy Foundation.

Beyond this restriction, Mr. Murphy placed no limitations on the use of the bequest, leaving to the board of trustees of the University the final decision as to future management.

Mr. Murphy expressed a desire that as much as possible of the principal should be held intact and used for endowment of the Institute. At the same time he empowered the trustees to spend portions of the principal from time to time, and all or any part of the annual income, for additional buildings, equipment, professorships, scholarships, books, research, and such other purposes as the trustees think necessary.

University of Iowa Film Library

THE University of Iowa Industrial Engineering Film Library of Motion and Time Study Films is now available for distribution on a rental basis. Films in this Library, originally established for use in connection with courses given by Ralph M. Barnes, professor of industrial engineering at the State University of Iowa, have been made available because of the many requests for them received from schools and from industries. All orders for these films should be sent to Bureau of Visual Instruction, Extension Division, State University of Iowa, Iowa City, Iowa.

(A.S.M.E. News continued on page 156)

OW TUBE-TURN
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NEFIT WAR
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The FIRST WELDING FITTINGS 1ST AND STILL THE BEST

Two ways that Tube-Turn welding fittings

avoid wasting men and hours in war plants

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TUBE-TURN fittings speed up piping installation four ways: (1) Need only butt-welds, easy for veteran or novice welders. (2) Less lining-up, for *uniform* walls and true circularity. pre-assembled on the ground save Torch cutting and fabricating are Tube-Turn fittings are ready to weld and weights for all needs.

You can depend on piping welded with Tube-Turn fittings to be practically maintenance-free, as Tube-Turn welding fittings give the *greatest possible strength* and *long life*. They're *permanently leakproof*. There are no bolts to loosen, no gaskets to replace, no threads to corrode and weaken.

No plant *ever* can afford a break-down or production slow-up, but in war-time it's a disaster! The best insurance in the world against trouble in piping systems is *welding* with *Tube-Turn fittings!*

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OTHER WAR-TIME ADVANTAGES:

SAVES CRITICAL MATERIAL: Absence of many flanges, bolts, nuts and heavy cast steel construction saves many tons of metal in a single piping system.

FASTER AND EASIER TO INSULATE: Tube-Turn fittings are insulated as easily as the pipe itself, for the welds form one continuous tube.

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LAST LONGER: Smooth inner walls—with no ridges, waves or scale—means less corrosion and longer life.

LESS PRESSURE LOSS: Because of full effective radius and exact O.D. and I.D. alignment with the pipe, the flow is more efficient and pressure loss is less.

FEWER SUPPORTS NEEDED: Since welded piping weighs less and stands vibration better than flanged systems, few hangers or supports are required.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to New York office.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

WORKS MANAGEMENT ENGINEER, 29, Draft 3A. Experienced in industrial engineering, desires executive or supervisory position leading to industrial management. Location, Middle Atlantic States or South. Me-785.

MECHANICAL ENGINEER with 20 years' engineering and production experience as factory manager, assistant factory manager, plant engineer, chief engineer; precision, high-production, heavy metal-working plants; machine shops, foundries, welding shops. Me-786.

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PRODUCTION MANAGER with at least 5 years' experience, particularly in automatic machine work. Company also operates small-parts foundry. To $10,000 year. Permanent. New Jersey. W-1589.

DESIGNER. Prefer electrical-engineering graduate to design power transformers up to 100 kva and other radio power equipment. $5000–6000 year. Permanent. New Jersey. W-1602.

PRODUCTION SUPERINTENDENT, 35–45, for mass-production metallurgical specialty plant employing about 200. Must be production-minded, capable of working to close limits in quality and unit cost. Prefer either mechanical or industrial degree and experience in mass production rather than production of job-shop type. Need not be in metallurgical industries. Permanent. $4800 year, plus monthly bonus. Eastern Pennsylvania. W-1604.

PLANT ENGINEER, 40–50, in charge of maintenance division of engineering department, about 75 men. Prefer man with knowledge of hydraulic presses, ceramic products, driers, kilns. Permanent. $4000–$5000 year. New Jersey. W-1616.

MECHANICAL ENGINEER experienced in manufacture of drums or cans for foreign work on government contract. $6500 year plus all living and travel expenses. Foreign. W-1618.

PRODUCTION MANAGER AND CHIEF ENGINEER, preferably one man, possibly two, for factory employing 450 workers. Incentive wage system, material control, and perpetual inventory are established. Salary open; for man capable of handling both positions, $10,000 year. New York, N. Y. W-1633.

MAINTENANCE ENGINEER with considerable experience in industrial maintenance. Will be in charge of pipefitters, carpenters, electricians, and mechanics. Should have some industrial boilerhouse experience. Permanent. $3600–$4200 year. New Jersey. W-1634.

ENGINEERS. (*a*) Assistant editor to prepare rough manuscripts for production in terms of organization, form, syntax, clarity, and correlation of text and plates; to rewrite text, prepare summaries and indexes, and do special editorial jobs for ordnance laboratory. (*b*) Production man who, after the editorial stage, will correlate and be responsible for production in final copy form of text and plates. Will be concerned with make-up and layout of titles, text, and illustrative plates and handle contacts with authors and their superior officers in co-ordination of these matters from the editorial stage through ultimate production. Washington, D. C. W-1650.

SHOP SUPERINTENDENT, 40–50, mechanical-engineering degree, with considerable machine-tool and shop experience. $7500, approximately, year. New Jersey. W-1670.

TRAFFIC ENGINEER acquainted with all types of plant transportation and conveyer equipment. Must be qualified to recommend proper type of material-handling equipment for plant working on high production schedule. Salary open. Northern New Jersey. W-1674.

ENGINEERS. (*a*) Associate engineer with extensive experience in servicing Freon refrigerating equipment of all sizes. $3200 year. (*b*) Refrigeration engineer, graduate, with broader experience in design, installation, service, and maintenance of Freon equipment and ability to assist in correcting any design or operating problems connected with refrigerating equipment. $3800 year. (*c*) Senior engineer well versed in Freon equipment and capable of supervising and directing a small force of refrigeration engineers. Should be able to plan maintenance programs, anticipate, and prepare against troubles that might develop with equipment installed. $4600 year. Some traveling. Should locate in Southeastern section of the U.S. Georgia. W-1679.

DESIGNER, mechanical, with ability to go ahead without too much supervision. Steam engines, internal-combustion engines, compressor or reciprocating-machinery experience desirable. About $4800 year. Location, western Pennsylvania. W-1684-D.

MECHANICAL ENGINEERS, not necessarily graduates, but men with good groundwork in fundamentals of mechanics. Several types required. Men with experience in heat transfer, armaments, gun or torpedo-installation equipment, hydraulics, aeronautical wing or fuselage, sheet-metal layout, knowledge of mechanisms, strength of materials, or stress analysis. Employer would be intensely interested in men with experience in one or several of the above types of work. Prefer men with 3 to 5 years' experience on board and who are of mature age; must be over forty. Employment will be in aeronautical industry. Permanent. Write Personnel Service for application blank. Location, East. W-1690.

DEVELOPMENT ENGINEER, mechanical, with several years' experience in development of small and medium-sized machinery. Must be fully qualified to carry through complete design from an idea. Only highly qualified engineer wanted. Salary open. Conn. W-1691.

PRODUCTION ENGINEER, young, although older qualified man would be considered. Prefer graduate mechanical engineer with experience in machining, punching, and finishing operations. Position is with old established organization and definitely permanent, with good opportunity for advancement. New York, N.Y. W-1692.

PRODUCTION MANAGER, 38–50, preferably graduate. Must be experienced in setting up and operating master production-control system, have job-shop experience in manufacture of large products, and must be experienced on heavy or semiheavy machine tools. Machine-shop experience preferred. Good knowledge of brass and foundry work. Ability to select, develop, and direct subordinates. $7000–$10,000 year. Pennsylvania. W-1693.

CHIEF ENGINEER for large instrument manufacturer with particular emphasis on production and choice of materials. Will be in direct charge of drafting and designs, only to get drawings completed to expedite production. $7500–$10,000 year. New Jersey. W-1695.

MECHANICAL ENGINEER for research and development work on machines and machinery; also on instruments. $4600–$4800 year. New York metropolitan area. W-1697.

MECHANICAL ENGINEER with minimum of 10 years' experience in machine tools and tooling of various metal plants to survey operating plants along these lines for government. Must be capable executive and have held responsible position in metal-manufacturing plant. Will accept either application for commission or civilian appointment. Salary for latter, $4600–$6500 year. Headquarters, Washington, D. C. W-1715.

SALES MANAGER, 32–45, for company making machines for testing strength of materials. Should have engineering degree; be able to write good business letters, make his own quotations. $7200 year. Illinois. W-1716-C.

RAILROAD SERVICE ENGINEER to sell lubrication and service an essential line of products to railroads in the Middle West. Requirements call for man 30–45 years of age, draft-exempt, preferably graduate mechanical engineer with number of years' practical experience in motive-power or other operating department of railroads, or in sale or service of rolling stock or heavy mechanical equipment for railroads. Permanent with headquarters in Chicago. Approximately $4200 year. Write fully, with complete facts of age, education, experience, salary required, draft status. R-1269-C.

(*A.S.M.E. News continued on page 158*)

[1] All men listed hold some form of A.S.M.E. membership.

This is the way to win a battle in the desert

Libya and North Africa made it clearer than ever: THIS IS A WAR OF SUPPLY.

In 1918, an American soldier could be equipped and maintained on 5 tons of supplies each year.

But today, for every soldier sent abroad, *10½ tons* of shipping space must be provided for *equipment alone*. And it takes an additional *18 tons of shipping to supply a single soldier for a year!*

Supply is a matter of *ships*.

And ships need electricity.

Vast quantities of electric power, for a thousand vital tasks that must be done to take a convoy safely across the seas...

Electricity to steer the vessels and operate the radios and signal lights.

Electricity to detect the approach of enemy subs and planes, to sound the alarm, to organize the defense.

Electricity to power great cargo winches, and delicate navigating instruments.

Electricity to make magnetic mines harmless, to provide invisible "black light" for reading charts at night. Electricity to keep food fresh, to cook it, to ventilate the ships, to provide comfort for the crews.

Electricity in every freighter, every tanker, every Navy escort vessel—to help win the war of supply!

We of Westinghouse take tremendous pride in building so much of the electrical equipment, so many of the great turbines and gears and electric drives, for the ships of America's Navy and Merchant Marine.

Into every piece of that equipment go all our "know-how," all our skill, all our determination to *do our share* in this war—and if possible, a little more.

Westinghouse Electric & Manufacturing Company, Pittsburgh, Pennsylvania.

Tune in the Westinghouse Program starring John Charles Thomas — NBC Network, Sunday, 2:30 P. M., Eastern War Time.

Westinghouse

PLANTS IN 25 CITIES — OFFICES EVERYWHERE

Index to 1942 Volume of Mechanical Engineering

AS Section 2 of the January, 1943, issue of the Transactions of the A.S.M.E., separate indexes to the Transactions and to MECHANICAL ENGINEERING for 1942 were mailed to the A.S.M.E. membership.

An additional copy of the index to MECHANICAL ENGINEERING may be secured from A.S.M.E. Headquarters, 29 West 39th Street, New York, N. Y., by sending ten cents for handling charges.

This Month's Cover

THIS month's cover, symbolic of the influx of women into men's jobs in all industries, shows Miss Berniece Williams at work among draftsmen at one of the plants of the General Electric Company. She is one of 54 women who have been graduated since 1940 from a "vestibule" draft course at Schenectady, N. Y. In these classes being held at present, 17 of the 26 students are women. By the end of 1943 it is expected that 300 women will have been graduated from the training course.

And this is perhaps as appropriate a time as any to give credit to the General Electric Company for our August, 1942, cover. We are a bit late with this acknowledgment but the omission in the first place was a "mergenfeller" job.

To Receive Jeffries Award

EDWARD C. SCHNEIDER, professor of biology at Wesleyan University, Middletown, Connecticut, since 1919, has been selected to receive the John Jeffries Award for 1942 given by the Institute of the Aeronautical Sciences for his pioneering research in the field of aviation medicine, particularly the development of the Schneider Physical Fitness Index, a method that has been in use for over twenty years in Army, Navy, and civil aviation for testing the condition of pilots.

Color Code, Lubricants

THE War Production Board and the National Machine Tool Builders Association have requested the American Standards Association that work be started at once on a standard color code for lubricants, as a War Emergency project. Purpose of this standard will be to indicate by color the grade of grease or oil to be used in a given part of a machine, thereby preventing costly mistakes on the part of the operator. Standard color markings will be applied to the machine part to be lubricated and to the container carrying the lubricant required for that part.

Music in Industry

CREDIT should have been given in our January issue to the Management Division of the A.S.M.E. which was responsible for the presentation of the article "Music in Industry" (pages 31–34) before the Metropolitan Section of the Society.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 25, 1943, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ALLEN, EDW., West Englewood, N. J.
AYRE, ROBT. E., Louisville, Ky. (Re)
BARKER, C. H., Washington, D. C. (Rt & T)
BEAM, ALBERT, Detroit, Mich.
BEIER, KURT A., Indianapolis, Ind.
BOOKOUT, E. J. Abington, Pa.
BROCK, EDW. J., St. Louis, Mo. (Rt)
CAMMER, MOSES, Arverne, N. Y.
CHAO, P. H., Chattanooga, Tenn.
DEAN, REEVE W., East Aurora, N. Y.
DONLEY, E. H., Mt. Vernon, N. Y.
DRYNAN, ARTHUR C., Scranton, Pa.
DUFFY, JOHN R., Detroit, Mich. (Re)
DUNLAP, ROBT. H., New York, N. Y.
DUNNE, S. B., Newton, N. J.
DURSI, GEO. A., Springfield, Mass.
DUSENBURY, WM. H., Bogota, N. J.
EASTMAN, A. R., Chuquicamata, Chile
ENGLER, C. R., Kingston, Ont., Canada
ENTZ, THEO. B., Knoxville, Tenn.
FIELDS, DAVID E., Tulsa, Okla. (Rt & T)
GORDON, E. M., Providence, R. I. (Rt & T)
HAYDEN, RALPH T., Covington, Va.
HODSON, W. H., Chicago, Ill.
JOHNSON, ALBERT M., Streator, Ill.
JOHNSTON, WM. S., Springfield, Mass. (Rt)
JONES, FREDK. S., New York, N. Y.
KELLER, ERNEST G., Glendale, Calif.
KINNEY, W. S., Cincinnati, Ohio
KNIGHT, FREDK. D., Boston, Mass. (Rt)
KNIGHT, WILLIAM, St. George, S. I., N. Y.
KOSKAN, ALLEN J., Barberton, Ohio
LANGER, B. F., Pittsburgh, Pa.
LINDSAY, DONALD L., Ottawa, Ont., Canada
MEDLEY, HAROLD C., Columbus, Ohio
NIEMAN, H. C., Pittsburg, Calif.
OLSON, ROBT. G., New York, N. Y.
PADDOCK, STEPHEN G., Lakewood, Ohio
PHILLIPS, PHILIP H., New Castle, Ind. (Rt & T)
POPE, CHAS. L., Rochester, N. Y.
POSTLEWAITE, WM. R., Palo Alto, Calif.
PRENZLAU, JOHN H., Chicago, Ill.
RAUCH, CARL, New Orleans, La.
ROSENBAUM, ARTHUR G., Louisville, Ky.
SCHUMACHER, CHAS. B., Pittsburgh, Pa.
SOMMER, WM. B., Palo Alto, Calif.
SPANG, F. J., Butler, Pa.
STAINTON, ROBT. S., Peoria, Ill.
TERJESEN, LEIF, Weehawken, N. J.
THOMPSON, COLLINS, Deepwater, N. J.
VANDERBILT, DONALD H., New York, N. Y.
VAN NOSTRAND, ERWIN S., Bethesda, Md. (Rt & T)
WALTZ, DALE A., Morgantown, W. Va.
WINEMILLER, DORSE E., Wadsworth, Ohio
ZEITNER, JESSE J., New York, N. Y.
ZOLNIK, BENJ. B., New York, N. Y.
ZORN, W. G., Chicago, Ill.

CHANGE OF GRADING

Transfers to Member

FILLMAN, CHAS. W., Cleveland, Ohio
LEDGETT, LOWELL A., Ridgewood, N. J.
SAWYER, W. H., New York, N. Y.
SNOW, WARREN S. (LIEUT.), Worcester, Mass.
USHER, SIR GEO. C., Berkshire, England

Necrology

THE deaths of the following members have recently been reported to headquarters:

BROWN, HARRY W., September 18, 1942
CONNOLLY, JAMES H., July 5, 1942
COOKE, HARTE, December 13, 1942
DOLL, CLYDE J., December, 1942
FISCHER, A. K., November 5, 1942
HARTMAN, L. G., July 4, 1942
JOHNSON, DAVID C., December 19, 1942
PICQUET, CHARLES A., October 10, 1942
PORTER, JOSEPH F., November 7, 1942
PRINDLE, EDWIN J., December 17, 1942
STAHL, NICHOLAS, January 1, 1943
VAUGHAN, HENRY H., December 11, 1942
WEEKS, PAUL, December 20, 1942

A.S.M.E. Transactions for January, 1943

THE January, 1943, issue of the Transactions of the A.S.M.E. contains:

Strength Characteristics of Plastic-Bonded Plywood, by G. R. Parsons
Bearing Strength of Plastics and Plywood, by James Bond
Applications and Unusual Physical Properties of Synthetic Rubbers, by O. D. Cole
Metal Cutting With Abrasive Wheels, by W. B. Heinz
Pulverized Coal for Forge Furnaces, by R. B. Engdahl and F. E. Graves
The Corrosion of Stressed Alloy-Steel Bars by High-Temperature Steam, by H. L. Solberg, A. A. Potter, G. A. Hawkins, J. T. Agnew
Automatic Uniform Rolling-In of Small Tubes, by F. F. Fisher and E. T. Cope
Heat Transfer and Fluid Resistances in Ljungstrom Regenerative-Type Air Preheaters, by Hilmer Karlsson and Sven Holm